INVESTIGATION OF THE EFFECTS OF SPORT, EXERCISE AND RECREATION (SER) ON PSYCHOSOCIAL OUTCOMES IN INDIVIDUALS WITH DISABILITIES

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Sport, exercise and recreation continue to be an important tool for health, fitness and social change as well as for individual rehabilitation. The concept that someone with a disability can be athletic and compete at high levels of sport has helped remove the stigma of being sick that was long been associated with a physical or cognitive impairment. Despite a surprising lack of scientific evidence, sport and recreation has been used to augment and enhance rehabilitation programs for well over 50 years. Clinical experience and anecdotal accounts report that people that participate in sport, exercise and recreation (SER) have fuller and healthier lives, with increased psychosocial well-being and improved quality of life. While there have been countless stories of positive life changing experiences related to involvement in adaptive sport and recreation there is a paucity of scientific evidence to support these claims.

As disability rates continue to rise throughout the population funding for rehabilitation programs is steadily decreasing and patient stays are getting shorter and shorter. Due to these issues treatment plans may not be as comprehensive as would be considered optimal and patient outcomes can suffer. Medical providers are continually looking for the most effective way to provide the best possible care and maximize patient outcomes.

Developing an evidence base to support the benefits of (SER) will serve multiple purposes. First it would help to educate medical providers and assist them in developing the most effective treatment plans and rehabilitation programs, allowing them to make the best use of available time and resources. Second, it would provide a knowledge base to train outside programs, trainers, and coaches as to what is most effective as the majority of these individuals are generally not medical providers. Third, it would serve to educate third party payers and possibly lead to reimbursement for equipment and services. Most importantly it would provide an avenue for Veterans with disabilities to return to a fuller, healthier life.

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PREFACE

I would like to thank everyone who helped me through my graduate program. I would like to give special thanks to the clinical coordinators especially Emily Teodorski whom without her hard work and dedication this would not be possible. Many thanks to the clinicians from the VA Pittsburgh Healthcare System especially Chad Evans and Martin Hampton for their understanding and flexibility. Without the help of many colleagues from the lab, friends and faculty members I could not have finish all the tasks assigned to me.

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1.0 INTRODUCTION

Sport and recreation is a corner stone of how we define ourselves as human beings and the competitive spirit is just as prominent in individuals with disabilities as it is in their able-bodied counterparts. Wheelchair sports were initially developed following WWII as a rehabilitation tool to care for the young men and women injured during the war. Today athletes with disabilities are narrowing the gap in competition between the impaired and the unimpaired through training, advancement of technology, and the competitive spirit and ingenuity of the seated athlete. Detrimental physical and psychological effects related to disability are well documented in the literature. As disability rates continue to rise throughout the population funding for rehabilitation programs is steadily decreasing and patient stays are getting shorter and shorter. Due to these issues treatment plans may not be as comprehensive as would be considered optimal and patient outcomes can suffer. Medical providers are continually looking for the most effective way to provide the best possible care and maximize patient outcomes.

Sport and recreation has been used to augment rehabilitation programs for decades fueled by clinical evidence offered in the form of testimonials provided by patients, adaptive sport and recreation participants, and medical providers. While there have been countless stories of positive life changing experiences related to involvement in adaptive sport and recreation there is a paucity of scientific evidence to support these claims. That is not to say that there has been no research conducted in the area of adaptive sport and recreation. However studies tend to have problems with methodology, limited sample size or both. Proponents of sport and recreation as rehabilitation cite decreases in depression and increases in self-esteem, posttraumatic growth (which refers to positive psychological change experienced as a result of the struggle with highly challenging life circumstances such as a disability), and overall quality of life (QOL) as some of the possible positive outcomes related to participation in sport and recreation for both the able-bodied and disabled populations.

Developing an evidence base to support the benefits of sport and recreation will serve multiple purposes. First it would help to educate medical providers and assist them in developing the most effective treatment plans and rehabilitation programs, allowing them to make the best use of available time and resources. Second, it would provide a knowledge base to train outside programs, trainers, and coaches as to what is safe and effective as the majority of these individuals are not medical providers. Third, it would serve to educate third party payers and possibly lead to reimbursement for equipment and services. Most importantly it would provide an avenue for Veterans with disabilities to return to a fuller, healthier life.

2.0 TECHNOLOGY TO IMPROVE SPORTS PERFORMANCE IN WHEELCHAIR SPORTS

Sport and recreation is a corner stone of how we define ourselves as human beings and the competitive spirit is just as prominent in individuals with disabilities as it is in their able-bodied counterparts. Wheelchair sports were initially developed following WWII as a rehabilitation tool to care for the young men and women injured during the war. Today athletes with disabilities are narrowing the gap in competition between the impaired and the unimpaired through training, advancement of technology, and the competitive spirit and ingenuity of the seated athlete. This article examines a number of factors related to maximizing performance and the prevention of injury in wheelchair sport. Physical and technological considerations for various wheelchair sports will be discussed including; metabolic demands, equipment selection, configuration, advances in technology and performance measurement as well as directions for future research.

2.1 WHEELCHAIR SPORTS

In terms of competitive sports, it is essential to utilize a multidisciplinary approach to reach the individuals fullest athletic potential. Before customized equipment can even be considered the team must work to maximize the athletes' physical potential. Only after training has optimized human performance can proper competitive adaptive sports equipment be determined. Regardless of the impairment or the sport the athlete wishes to participate in, initial training should work to improve strength, endurance, flexibility and functional mobility in order to approach a high level of physical conditioning. Athletes should be encouraged to try a number of different activities before completely investing themselves in one sport. Throughout this period the athlete should try as many different pieces of adaptive equipment (depending on the sport) as possible to see what works the best for him or her. There are a number of adjustable multi-sport chairs available that allow individuals to participate in various sports while investigating different settings utilizing only one piece of equipment. Once the athlete determines that they wish to be competitive in their chosen sport and has been able to try different models and settings to see what works best for them then specialized equipment can be purchased or developed to enhance the athletes' performance.

Performance during competition using a wheelchair is directly related to chair mechanics (mass, mass distribution, wheel/tire characteristics, and alignment), maintenance of the wheelchair, chair/ user interface, and work capacity of the athlete. As such this article will review seating technology related to wheelchair sport, metabolic demands of the wheelchair athlete, equipment available to quantitatively obtain and assess data during practice and competition, and current and future research needs related to wheelchair sports.

2.2 METABOLIC DEMANDS OF THE WHEELCHAIR ATHLETE

This section will focus on the altered metabolic demands of the athlete with a spinal cord injury as they represent a significant portion of the wheelchair athlete population and individuals who participate in wheelchair sports with other disabilities such as traumatically amputated limbs would have metabolic demands similar to an unimpaired athlete [1]. Athletes with damage to their spinal cord may participate in international competition if there is at least a 10% loss of function in the lower limbs. Understanding physiological demands of wheelchair sport is essential to developing sound testing, coaching, and training programs to ensure maximization of athletic performance in parallel with their unimpaired counterparts. Unfortunately, there is a significant gap in evidence based performance training between unimpaired and athletes with disabilities. Potential reasons for this discrepancy is lack of trained professionals including coaches, trainers, and rehabilitation practitioners not due to the lack of interest in seated sport but more likely the scarcity of evidenced based knowledge available. Training principles employed by for the able-bodied (AB) athlete are not directly transferable to the wheelchair athlete and effective training principles for wheelchair athletes are still being developed [2]. There has been an increase in research related to adaptive sport over the last 2 decades leading to more effective training and coaching of disabled athletes [2, 3].

To understand the alterations in metabolic demands of the wheelchair athlete some basic knowledge of anatomic and physiological changes associated with damage to the spinal cord is required. There will be some degree of damage to the Central Nervous System. The somatic nervous system innervates and controls voluntary movements. The autonomic nervous system has two divisions. The parasympathetic nervous system which works to restore homeostasis by slowing the heart rate, reducing blood pressure, and preparing the body for rest. The sympathetic nervous system mediates the body‘s response to stress. The fight-or-flight reaction elicited by the sympathetic system is essentially a whole body response. Changes in organ and tissue function throughout the body are coordinated so that there is an increase in the delivery of well-oxygenated, nutrient-rich blood to the working skeletal muscles. Both heart rate and myocardial contractility are increased so that the heart pumps more blood per minute. Sympathetic stimulation of vascular smooth muscle causes widespread vasoconstriction, particularly in the organs of the gastrointestinal system and in the kidneys. This vasoconstriction serves to redirect or redistributes the blood away from these metabolically inactive tissues and toward the contracting muscles. Bronchodilation in the lungs facilitates the movement of air in and out of the lungs so that the uptake of oxygen from the atmosphere and the elimination of carbon dioxide from the body are maximized [4]. The higher the level and the more complete the lesion the more pronounced the loss of somatic and autonomic function and the more difficult it is to exercise at metabolic rates high enough to challenge the cardiopulmonary system and produce a training effect. A significant impairment of the sympathetic division negatively affects athletic performance by affecting smooth muscle regulation (impairing the ability to increase blood pressure) and by diminishing the capacity of the heart rate to increase during vigorous activity especially individuals with high thoracic or cervical spinal cord injuries that no longer have the capability of increasing the heart rate. However, athletes with spinal cord injuries have found an effective yet dangerous way of overcoming this lack of sympathetic response. Many athletes with spinal cord injuries who compete in events such as wheelchair racing have been known to voluntarily induce Autonomic Dysreflexia in order to produce a massive sympathetic discharge prior to competition. This Boosting‘ is done by inducing some sort of nociceptive input (over-distending the bladder, sitting on sharp objects) approximately 1-2 hrs before the competition. While improvements in wheelchair racing time have been reported the practice is extremely dangerous and considered unethical and illegal by the International Paralympic Committee [5, 6].

As a result of the spinal cord lesion there is marked atrophy of the paralyzed musculature with a con-commitant increase of perimysial tissue. The paralyzed musculature below the level of the lesion shows a transformation from type I to type II fibers with accompanying metabolic changes such as decreased oxidative enzyme activity and mitochondrial content [7]. These changes will limit the oxidative capacity of the exercising musculature and limit the athletes' ability to be competitive in endurance events that require long-term energy sources. Metabolic and anatomic changes are most likely due to lack of mechanical loading, limitations in neuromuscular stimulation, decreased tension, and reduced oxygen demand.

Increased cardiac output and pulmonary activity occur during exercise to meet the metabolic needs of muscles. Cardiac function is often affected with reductions of greater than 25% in ventricular dimensions consistently found in individuals with tetraplegia (this reduction is more prominent in the left ventricle) [8]. There are also associated changes within the vascular and pulmonary systems. There is a reduction in the diameter in the vasculature servicing the paralyzed musculature as well as a contrasting increase in the diameter and blood flow of the upper limbs. The loss of innervation of the respiratory musculature is dependent on the level and completeness of the injury. In injuries below the C4 level innervation to the diaphragm and sternocladiomastoid is intact and the individual can breathe independently, however increased oxygen demand during sport can be difficult and must be monitored. In individuals with tetraplegia lung volume is decreased with the most significant reduction seen in Vital Capacity [9]. Prolonged exercise is made possible by the human thermoregulation capacity to remove exercise waste heat by sweat evaporation. One gram of sweat can remove 2,598 J of heat energy

[10]. Depending on the level of the lesion this capacity is severely compromised which can lead to fatigue, cognitive impairment, heatstroke, and even death.

As in all athletics energy demands of wheelchair sports are generally differentiated by intensity and duration. High intensity activities of short duration such as sprinting (100m wheelchair race) or throwing events (seated discus, shot put, or javelin) tax the Phosphagen system. This system relies on the chemical reactions of intramuscular Adenosine triphosphate (ATP) and creatine phosphate (CP) to produce energy. High-intensity aerobic exercise close to 100% of the energy is derived from carbohydrate utilization, however during prolonged, sub maximal, steady state work there is a gradual shift back to fats and protein as energy substrates. The Oxidative (aerobic) system is the most efficient and is capable of producing well over 100 ATP molecules per unit of fatty acids [15]. Although there are differences such as elevated free fatty acid levels during prolonged exercise and alterations to blood lactate levels in athletes with spinal lesions the overall pattern of substrate utilization is consistent with that observed in able-bodied individuals.

This is only a brief overview of some of the identified metabolic factors in athletes with spinal lesions. Obviously more research needs to be conducted, especially on acute metabolic changes during competition as well as post-competition recovery. This data will allow us to develop optimal training programs, prevent over-training and possible injuries.

2.3 WHEELCHAIR SPORTS SEATING AND SPORTS SPECIFIC WHEELCHAIRS

The goals of seating systems in wheelchair sports extend far beyond the postural and pressure relieving goals of a seating system in an everyday chair, and can vary widely across different wheelchair sports. This should be unsurprising, since the equipment among unimpaired athlete varies widely depending on which sporting activity: one would never run a marathon in rugby shoes. Similarly, the equipment described throughout this article and the seating is highly specialized to the person, the sport; and in some cases like basketball and rugby, the position the athlete plays. Besides applying the latest technologies to sports equipment to compensate for decreased function, customized equipment attempts to fit each athlete intimately so that the participant may utilize that equipment as an extension of his/her body. A sports wheelchair enables mobility challenged athletes to participate in their desired sporting activities with decreased restriction. Competitive and recreational sports chairs typically fall into one of four major categories; hand-cycles, court chairs, all terrain wheel chairs, and racers. Individual differences in body structure and physical ability are emphasized in designing sports equipment to gain mechanical advantage and prevent wasted energy. Failure to fit the equipment to the athlete may result in poor performance and predispose the individual to accidents or injuries. Appropriate wheelchair selection and settings will contribute to optimizing sports performance as well as protecting the athlete from possible negative effects including blunt force and repetitive strain injury. Below we discuss the key principles in sports seating for several popular wheelchair sports, taking into consideration aspects of configuration, mobility, and pressure relief.

2.4 BASKETBALL

Wheelchair basketball like its standing counterpart is a fast moving and exciting sport. Agility (achieving rapid responses in acceleration, braking, and turning), overall speed, and stability are keys to gaining the advantage in wheelchair basketball games [16].

Figure 1. Wheelchair Basketball. This picture is from the Web site of the Department of Veterans Affairs (http://www1 .va.gov/vetevent/nvwg/2008/default.cfm).

Seating for wheelchair basketball is intimately related to the desired outcome, which is to have fun, be competitive, and more often than not, win. In general, decreasing rolling resistance when moving forward, turning and improved wheelchair response are the goals when setting basketball wheelchairs.

There are several ways to lessen rolling resistance: decreasing the weight of the whole system, optimizing the mass distribution over the wheels, increasing the diameter of the wheels, ensuring exact rear-wheel alignment, and reducing deformation of tires and castors at the contact points on the ground are among the most prominent. Lightweight frames and wheels are essential. Stiffer tires and casters that deform less when rolling on the ground help to decrease rolling friction. Rear wheels of 61 cm (24 inches) or 68.6 cm (27 inches) in diameter with high-pressure tires are commonly used. The front casters are mainly solid polyurethane and 5 cm (2 inches) in diameter to ensure caster-foot clearance. When the player is sitting in the wheelchair and it is in the forward driving position, the maximum permissible distance between the bottom of the castor(s) and the playing surface is 2 cm [17]. No more than two anti-tip casters may be attached to the underside or rear part of the chair in games. Their rear borders cannot extend past any part of the rear wheels. Forward bumpers mounted on the footrest help to reduce the risk of forward falls and foot injuries due to front impacts. The protective horizontal bar at the front/sides of the wheelchair must be no higher than 11 cm from the floor at its most forward point and throughout its whole length [17].

Camber has been defined as the angle of the main wheels in relation to the vertical, whereby the distance between the top points of the main wheels is less than the distance between the bottom points [18, 19]. Having wheel camber and moving the rear wheel axles forward can improve players' accessibility to hand-rims. Camber angles currently selected by wheelchair athletes engaged in court sports generally range from 15 degrees to as much as 24 degrees [20]. There are dimensional changes that can occur due to these adjustments that can affect overall performance. While increasing camber protects the hands and allows easier access to the hand-rims rolling resistance increases with greater wheel camber because of the contact between the tires and the ground [21]. There are also physiological and biomechanical effects of camber angle. Mason et al (2010) found that 20 degrees and 24 degrees of camber improved the mechanical efficiency of wheelchair propulsion in trained wheelchair athletes, yet increased external power requirements and reduced economy [22]. The feeling of improvement in turning may be because users can reach the hand-rims more easily. There is a give and take with most adjustments made to the wheelchair so the characteristics of the sport and player preference need to be considered in the decision.

A forward rear wheel axle position decreases the total length of the chair, but the chair becomes less stable in its backward direction. Tipping backward may occur when the athlete extends or rotate his or her trunk backward to make a play on the ball, causing a quick rearward shift of the center of gravity. Athletes should be careful about adjusting the rear wheel axle position, especially those who have had their lower extremities amputated or have lost significant muscle mass and weight in the lower limbs. In athletes with lower extremities intact below the knee a hyperflexed knee position (knee flexed more than 90°, with 0° being full extension) increases turning speed [23].

Wheelchair configurations may differ according to the position of the player on a team (e.g., forwards or guards) as well as athlete preference. To manage the court and fend off opponents guards tend to set-up their chairs to be faster, more stable, with increased responsiveness and maneuverability. These demands can be achieved by increasing the rear wheel camber angles and seat dump angles, and moving rear wheel axles forward, yet the seat height will thus decrease. Forwards usually set their seat as high as possible (within regulation) in order to maximize blocking and decrease the distance to the basket. The maximum height from the floor to the top of the cushion, when a cushion is used, or the top of the seat platform, when a cushion is not used must not exceed: 63 cm for players 1.0-3.0 and 58 cm for players 3.5-4.5 [4]. Seat height has been shown to significantly effect mechanical efficiency (ME), oxygen cost, push range, and push duration [24]. Increasing the vertical distance between the seat and the rear wheel axle, and decreasing the seat dump angle and rear wheel camber angles can raise the seat height. However, these settings may make the chair have less lateral stability and decrease the player‘s range of access to the handrims.

Backrest selection needs careful consideration of the balance between providing support to the trunk and maximizing freedom of motion for the trunk and upper extremities. The trunk and upper extremities have more freedom of movement when the backrest is lower. Solid backrests provide better stability, but some players prefer sling backrests for the feeling of better contour around their trunks. Due to high speed and high frequency of trunk movements, the edges around the backrest tend to induce high pressure and friction against the skin, especially around the backrest posts. These edges should be padded to prevent skin damage.

The strength and durability of a wheelchair are important issues from the perspectives of safety, cost-effectiveness, and consistency of play. If during a game a wheelchair becomes non-functional or unsafe the referee will stop the game and allow a maximum of 50 seconds to repair the chair. If the repair cannot be completed in 50 seconds or less from the time the game was stopped the player must be substituted. Exposed spokes of wheels is a weakness in a wheelchair. Opponents may illegally ram exposed spokes to disturb play. Spoke guards made of high-impact plastic cover the rear-wheel spokes not only to prevent wheel damage but to protect players' hands and fingers from being trapped in the spokes. With spoke guards, basketball players can pick up the ball from the floor more easily by pushing it against the spoke guard and rolling it onto their laps. More detailed equipment requirements are documented in the rules of wheelchair basketball by the National Collegiate Athletic Association [17].

2.5 RUGBY

Wheelchair rugby, otherwise known as Quad Rugby or Murderball thanks to a popular documentary by the same name, was developed for people with physical limitations involving both upper and lower extremities. Many of the players at present have tetraplegia due to sustained cervical-level spinal cord injuries. This sport is the combination of team handball and rugby. High impact contact is legal for either defense or offense during games. Similar to settings of basketball wheelchairs, achieving rapid responses in acceleration, braking, and turning is the main goal for rugby wheelchair setting. However, rugby wheelchairs require more modifications to withstand heavy impacts and maintain players' sitting balance.

Figure 2. Wheelchair rugby. This picture is from the Web site of the Department of Veterans Affairs (http://www1 .va.gov/vetevent/nvwg/2008/default.cfm).

The principles of selecting frames, wheels, and casters for rugby wheelchairs are the same as those for basketball wheelchairs. To withstand high velocity impacts and severe chair damage, rugby chairs are equipped with metal guards or wraps to cover wheel spokes and lower frame tubes. Although this protective equipment adds more weight to a chair, the extra weight may provide more inertia to prevent the chair from being blocked or pushed away. Like other team sports wheelchair configuration is dependent on position and preference. Offensive players want faster, more maneuverable chairs, designed to elude the defense and easily disrupt their attacks. In contrast defensive chairs are designed to dish out punishment and obstruct offensive play. Defensive players accomplish this by attempting to block and ―hook‖ the chairs of offensive players by using extensions of no longer than 11cm built into the front of their own chairs.

A wheelchair for playing rugby needs to have very stable configurations for the player‘s sitting balance and the whole wheelchair system. The rear wheels are radically cambered from 15 to 24 degrees to create a larger base of support. Metal guards covering lower frames and wheel spokes help to stabilize the chair by lowering the center of gravity of the whole wheelchair system. There is no official rule limiting the use of anti-tip casters. The seat angle may be set as much as tilting 20 degrees backward to provide maximum pelvic stability. Contoured seat cushions and pelvic belts help to secure the pelvic position. Recently a number of athletes have shifted to an ergo-seating design built into the frame that allows greater pelvic stability while decreasing posterior pelvic tilt and sacral sitting. Some players with higher-level lesions may wear trunk belts to obtain better trunk stability.

Backrest height is selected based on impairment type/level and position (defensive/offensive) to balance the need for stabilizing the trunk while maximizing the athletes' arm-reach (to catch thrown balls and access the push-rim for propulsion). Athletes in offensive positions will often air on the side of greater arm-reach, while those in defensive positions will have increased postural stability to reduce the tendency of the wheelchair/athlete to flip during high impact due to the momentum of the body. Higher and harder backrests can provide better sitting stability but limit the range of movement of the upper trunk and limbs. Players may need to lean firmly against the backrest to gain counterforce for upper-limb movement; meanwhile, they have to move the upper trunk to increase the range that the upper limbs can cover. Caution must be taken, as large shear forces may occur along the edges of the backrest, especially the corners. Proper padding should cover these edges to distribute abrupt forces, and players should check the skin condition of their backs frequently.

Straps restricting lower extremities and solid thigh guards are used to stabilize lower extremities and the lower trunk. Broad straps are suggested to secure lower extremities. Narrow straps may create high local pressures on the skin and are more likely to block circulation. Kneepads or braces may be utilized for additional protection. Scratches, abrasions, and friction blisters on hands and arms are frequent injuries in wheelchair rugby. Gloves or hand taping are necessary preventive equipment that every player should wear. Players are allowed to put sticky glue on their gloves or tape to catch the ball more easily. Injury prevention is not the only reason players wear gloves. Studies have shown that wearing the proper gloves can effect aspects of performance such as acceleration and sprinting [25]. Cambered driving wheels and spoke guards also help to protect players' hands and fingers.

2.6 TENNIS

Wheelchair tennis has a very fast tempo, even when the two-bounce rule is applied. Because players have to do their best to cover the entire court, it is important that the wheelchair is fast and responsive. The goal of seating in wheelchair tennis is to permit full range of motion of the trunk (in all directions) to increase the athlete's ability to reach and hit the ball. There is often little or no seat-dump, to allow full flexion of the hip to reach low balls in front of the athlete. To compensate for the reduced pelvic stability (typically provided by seat-dump), the athlete is usually secured to the wheelchair with straps around their legs. The players‘ reach is also increased by keeping the backrest as low as possible, while still providing a rear block to stabilize the sacrum. The feet are often tucked up behind the knees to reduce the overall length of the wheelchair, maximizing the area in front of the athlete that they can increase access to the ball.

Figure 3. Wheelchair tennis. This picture is from the Web site of the New York City Sports Commission (http://www. nyc.gov/html/sports/html/jana_hunsaker_tournament_archive.html).

The drive wheels of 61 cm (24 inches) or 68.6 cm (27 inches) in diameter with high-pressure tires and solid casters of 5 cm (2 inches) in diameter are commonly used. Similar to basketball and rugby chairs, choosing lightweight frames and wheels is the primary principle to decrease the power demanded to propel the chair. To hit the ball, the player has to swing the racket and push or turn the chair with one hand at some point while using a controlled weight shift and hip snap. Drive wheels are cambered to allow the player to be able to cover a larger range on the handrims and thus to maneuver the chair agilely. Caution must be taken that increased wheel camber angles may increase the strength demand to propel the chair and decrease the seat height. In an adjustable chair a lower seat height may make the chair more stable, but the player would lose height advantage to increase serving speed. A higher seat height can also be used to improve the athlete‘s view of the court over the net. Some players modify their chairs to have a single front caster or even a single anti-tip caster to make the chair more responsive in turns, but stability in diagonal directions decreases with this setting. The use of taping between the racket and the hand is another important means of adapting equipment in the quad division.

A stable sitting position is the key to facilitate better tennis skills. Athletes should give all their attention to maneuvering the chair and hitting the ball but not to keep their sitting balance. Accessories such as rigid thigh guards, and solid backrests can provide better pelvic stability. Elite players may use extremely low backrests covering only the pelvic region but this requires practice and an amateur or even novice player may need to initially compromise some freedom of movement for more stability.

2.7 WHEELCHAIR RACING

The wheelchair and user interface remain critical issues, even with the significant advances in the availability and design of commercial racing wheelchairs [26-29]. The seating interface should fit tightly to the user. A simple test is that the seat should be silent when pushing at maximal speed/force. An ill-fitting seat has a tendency to make bunching or slapping noises. The trunk range of motion should be such that the athlete can get as low as possible, while still be able to breath, raise their chest off of their thighs, and to comfortably reach between 2 o'clock and 7 o'clock on the pushrim with both hands simultaneously. The interface between the hands and the pushrims remains poorly understood, and presents opportunities for further improvement. The hand-pushrim interface is influenced by the seating position, stability of the shoulder complex, the location of the axle with respect to the shoulder, the diameter of the pushrim, and the tubing size of the pushrim, to pushrim coating, the glove coating, and the design and fit of the gloves [30-32]. Athletes use a variety of hand positions and gloves styles as interfaces. There is also considerable need for increasing the understanding of wheelchair racing tactics. Unfortunately, there are insufficient opportunities for competitions at various levels for wheelchair track. Most track athletes prepare for and compete in road-racing much of the time, and then spend a few months participating in a small number of track competitions. Because of the differences between road racing and track tactics, many athletes have poor acceleration. Track is a sport of constant acceleration, with quick chopped strokes at the start transitioning to long-smooth-stroke at top-end. There can be no weak-link in the chain of acceleration. Athletes and coaches must learn to change the power curve to match the speed of the chair. Athletes need more work on the start-to-top-end transition. Transitions are often a weakness. Several elite athletes have developed a rapid-circular-stroke for turns. Coaches and athletes need to work on transitions and accelerations into and out of turns. Many road-racing athletes are too slow on transitions, where they need to hit top speed near the end of the transition out of a turn. Head-bobbing is a ready indicator that athletes are experiencing an unfamiliar scenario while racing, and their form has broken-down, and they are attempting to use brute strength and stamina to remain with their competitors. Videotaping athletes in competition and showing athletes their sagittal plane views in real-time, especially when overlaid on an optimal stroke model is an effective teaching technique. The head-neck-shoulder-complex needs to be relaxed but form a rigid base of support. It is important to work on high hand-height during the recovery phase to pre-load the muscles. At the end of the propulsive phase the hands should fly up and out, similar to the end of the butterfly stroke in swimming. Many road-racing athletes have inadequate hand-speed when transitioning to racing on the track. Winning track athletes have a remarkably wide range of cadence up to 150 strokes/min.

Figure 4. Picture of wheelchair racer

Athletes need to have a strategy for each race and a back-up plan. In international competition it is important to work as a team whenever possible. For example, have a plan for exchanges in taking the lead in a draft that is based upon the strengths of the teammates. Athletes should be able to respond to strategies by other competitors. Top athletes are not afraid to take the lead and to control the race. Too many athletes, even at the elite level, compete at too many distances in a single competition. It is more prudent to focus on the 100m/200m/400m, or the 800m and 1500m, or the 5,000m and 10,000m.

2.8 HAND-CYCLING

Hand-cycling is a rapidly growing sport and has already supplanted wheelchair racing in terms of the number of athletes participating at all levels of performance. The variety of hand-cycle designs permits accommodation of a wide range of abilities and physical characteristics. Hand-cycling is an easy activity to integrate with recreational bicycling along with friends and families. As a competitive sport, hand-cyclists typically use either a kneeling or recumbent seating system. The kneeling seating position is typically used by athletes with some trunk musculature. For example, athletes with lumber spinal cord injuries or lower-limb amputations. This has brought with it some controversy as the kneeling position allows greater musculature to be applied towards cranking, which helps with acceleration, hill-climbing, and when aggressively attacking a hill transition. Top speeds on level roadways for kneeling and recumbent seating positions are similar; this is likely to be due to the more aerodynamic position of recumbent seating. A particular challenge for hand-cyclists, with the possible exception of

Europe, is finding opportunities for competition. This challenge is exacerbated by the speeds attained by highly-trained and skilled hand-cyclists. In some cases, hand-cycles are considered "crank-wheelchairs" and compete in running marathons. Marathons are a reasonable distance for hand-cyclists of most ability levels to compete in and are similar in distance to the road-race distance in the Paralympic Games. Marathons tend to be a safe venue for hand-cycle competition as roads are typically closed to vehicle traffic. Some marathon organizers hesitate to admit hand-cycles as top athletes can complete the 42.5 km in less than 1 hr and 30 minutes, which may require longer-duration of road closures and more volunteer support. Bicycle races may seem more suitable, but most hand-cyclists are considerably slower and in all but the largest events that roads remain open for traffic in road races. Criterion races are notable exceptions that offer a closed-circuit, exciting competition, and thrills for spectators. Both Marathons and criterion races seem necessary in order to provide opportunities for hand-cyclists of all skill levels to exercise and to grow to their full athletic potential.

Figure 5. Picture of hand cyclist

There are a number of factors when considering how to optimize hand-cycle set-up and training. Kneeling hand-cyclists tend to use a wider crank width than do recumbent riders. Recumbent riders tend to gravitate towards crank widths that are approximately 0.04 m wider than the shoulder width, which allows the shoulder to be in a stable position during the push-phase. Kneeling cyclists may use a wider stance as they tend to use their trunk mass and musculature to apply force for the push-phase and the shoulders are used for stabilization as well as force application, but the force balance is altered. The wider arm stance may be advantageous in recruiting the lattisimus dorsi and pectoralis muscles in the kneeling position (i.e, similar to bar-dips), whereas, the pectoralis muscles are more active (i.e., similar to bench-press) in the recumbent position push-phase. Core strength is critical for hand-cyclists in the kneeling position to maximize the base of support for force application at the cranks. Because of the differences in the way forces are applied between the two seating systems, recumbent cyclists tend to use a higher crank cadence of somewhere between 80 and 120 strokes per minute. In theory, this results in a trade-off between the stress on the cardiovascular system versus and the prime movers. A higher cadence should be more taxing on the cardiovascular system and lower the forces on the skeletal muscles, this may favor the recumbent position. The problem comes when accelerating or climbing a hill. If one is at near maximal cadence (i.e., spinning) than there is little overhead for additional rounds per minute for acceleration or climbing hills. Kneeling cyclists tend to operate at 40 to 80 strokes per minute, likely because the larger muscles are not as efficient at higher turn-over, but can apply both higher force and cadence at the expense of efficiency when accelerating or hill climbing, much like coming out of the seat in a bicycle. Research is required to test this hypothesis.

Competitive hand-cycles have three wheels, two in the rear and one in the front. The front wheel is the drive wheel, which simplifies the design and lightens the hand-cycle. Hand-cycles typically use either lean steering (i.e., much like a skateboard) or arm steering. Arm steering is used most frequently by elite athletes because of the ease of making fine adjustments, and the greater lateral stability at high speeds. Lean steering can result in lateral instability due to positive feedback at the speeds attainable on down-hills. Essentially all elite hand-cyclists are concerned with minimizing strength without compromising stiffness. The easiest ways to accomplish this strength to weight optimization is to use composite wheels (e.g., disc or tri-spokes), lightweight components (e.g., derailleur, shifters, chain-rings, chain, and brake). Composite materials, titanium, and high-strength aluminum are all used by component manufacturers to minimize weight. Most frames are made from high-strength aircraft quality aluminum (e.g., 6061T6 or 7075). There are two basic frame designs. A uni-strut frame uses a single beam that runs under the seat, whereas a parallel strut design uses the frame to form the seat. Aluminum tends to fatigue with use, and therefore, elite hand-cyclists will start to feel the loss of snap in the frame and have it replaced about once per year. For other individuals, a hand-cycle will last several years.

2.9 THROWING CHAIR

Paralympic athletics include four throwing sports: shot put, discus, club throw and javelin. While both ambulatory and seated athletes participate in all throws, this section focuses on the seated thrower or classifications F3 1-34 and F5 1-58. There are few regulations on the frames used for seated throwing and several styles of frame designs have proliferated. An example is given in figure 6.

Figure 6. Picture of a traditional throwing chair courtesy of the Human Engineering Research Labs Pittsburgh VA

However, all frames must: have a seat height of 75cm or less (with or without cushion), use footrest for stability and support only, and not have any articulating joints. The frame may also have side rests and a holding bar made of metal, fiberglass, or similar material Hellwig, 2010).

Previous literature on throwing events for athletes with disabilities has mainly focused on the biomechanics of the throwing [33-39]. Chow et al, using video to capture the kinematics of the throwing motion, quantified the angle and speed during the release of the implement for the discus, shot put, and javelin events [33-35]. Frossard et al (2004) recorded throwing athletes at the 2000 Paralympics and made recommendations on how to optimally record video of throws for biomechanical analysis [38]. O'Riordan et al (2004), in study of foot placement in F33/F34 discus athletes, suggests that technique is unique to the individual and that throwing frames need to be extremely adjustable [39]. While some work has been done on the biomechanics of the throwing athletes, little research has been conducted on the throwing chairs themselves.

Current throwing chair designs are: difficult to secure to the ground, provide little support for the legs and feet, have few adjustable features, are easy to misalign with the sector when securing to the ground, and can be difficult to transfer from and back to the athletes' wheelchair. Recent efforts at the Human Engineering Research Laboratories have led to the creation of a highly adjustable throwing chair design that addresses these shortcomings [40]. A photograph and solid works model of the throwing chair are given in figures 7 and 8, respectively.


Figure 7. (Photograph of HERL throwing chair) ***Figure 8.*** (Solid works model of HERL throwing chair) These pictures are Courtesy of the Human Engineering Research Labs Pittsburgh VA

This new design has many adjustable features including: foot rest height and angle, backrest height and depth, pole angle and height, and seat height to accommodate different cushion heights. The design also incorporates two novel design features: knee blocks to better secure the thrower‘s legs, and a seat that can be rotated and locked in place, which allows the thrower to quickly adjust their angle relative to the sector. The placement of tie-down hooks for securing the chair are strategically placed so all the features can be adjusted after the chair has been secured to the ground.

The highly adjustable design has several benefits. The chair can accommodate throwers with a wide variety of function and it can be quickly adjusted and readjusted to optimize body position. Once secured to the ground, all adjustments can be made, which eliminates the need to remove securing straps and replacing them when switching between throwers. These benefits suggest the chair would be useful to programs or sport clubs where many throwers would be able to use one chair. Since the chair only needs to be secured once, practices and competitions with multiple athletes could be expedited, thus simplifying the logistics of these events and possibly allowing more throwers to participate. Future work on this design should include biomechanical and performance analysis studies to determine if this design can be used to help increase performance. Additional engineering work should focus on enhancing the designs transportability and improving the means of transferring into the chair.

2.10 PERFORMANCE MEASUREMENT

In the past decade, there have been a number of new technologies introduced to facilitate research and advance sports performance for people with disabilities. As these technologies become more widely available, there impact should grow to increase the understanding of the mechanisms that influence adaptive sports performance.

2.10.1 SmartWheel

The SmartWheel (Three Rivers Holdings, LLC, Mesa, AZ, USA) is a validated tool that analyzes manual wheelchair users push on the handrim. The SmartWheel measures the user‘s Push Forces, Push Frequency, Push Length, Push Smoothness, and Speed. The SmartWheel has been used in numerous studies to measure three dimensional forces and torque [41]. A standard SmartWheel weighs 4.9kg (1.1lb), which increases the weight of the wheelchair but this minimal increase is negligible considering that the SmartWheel provides measures of stroke length and force that can be measured in a clinical, community or sporting setting [42].

Rice et al. (2009) studied stroke characteristics of long-term manual wheelchair users during an extended manual wheelchair propulsion trial and the extent to which changes in propulsion biomechanics occurred. The study consisted of 21 subjects pushing at 1.4ms for 10 min while secured to a dynamometer. The target velocity presented was 1 .4ms in the value of a bar range. The results showed that subjects unexpectedly modified their propulsion biomechanics favorably from early to late in a 10-minute trial without technique coaching or feedback training [43].

The SmartWheel also has a clinical protocol that was designed to facilitate standardized data collection and contribute to a SmartWheel Users' Group (SWUG). The SWUG is an international group of over 30 researcher groups, clinics, industry leaders, advocacy groups, and end users from 4 countries, 12 states, 2 Veterans Administration hospitals, 1 Veterans Affairs center of excellence, 5 current or previous Model Spinal Cord Injury System center, 3 members of industry, and 1 advocacy group. The goal of the SWUG is the continuing development of practical methods to objectively assess manual wheelchair propulsion while maintaining evidence-driven, clinically meaningful, useful standards. A secondary goal of the SMUG is to facilitate mutually beneficial communication among the clinicians, end-users, and researchers [44]. The SMUG clinical protocol is a modular assessment that requires users to attach a SmartWheel unilaterally to the wheelchair and propel across level tile, low pile carpet, and up a ramp that complies with the requirements of the Americans with Disabilities Act (ADA) (maximum rise to run, 1:12; grade, 8.3%; slope, 5°. The final assessment requires users to perform a figure of eight on level tile [44]. Recently, a SmartWheel has been created to be suitable for wheelchair racing. It will allow for a greater expansion of the data collected by the SWUG for the purposes of training, coaching and injury prevention.

2.10.2 Data Logger

A miniaturized data logger (MDL) has been designed for collecting manual wheelchair activity and has been successfully used in several community based studies [45-48]. The MDL is a device that collects the distance traveled, average velocity, activity time, and number of starts and stops. Activity time is defined as the sum of time the wheelchair was in motion and a stop and start is defined as 2 seconds or more with no wheelchair motion. The average speed is calculated by dividing the total distance.

The MDL is used to collect quantitative data from actual game play, during wheelchair basketball and rugby [49]. The MDL‘s are attached to the spokes of the sport wheelchair in a location that does not interfere with propulsion, and does not impact game activity. Once the MDL was removed from the athlete‘s wheelchair after cessation of the basketball or rugby tournament, the data was downloaded and analyzed using MATLAB 2007b and SPSSv15. The average data of two games was calculated for consistency. Over the course of two games, the wheelchair rugby athletes on average traveled 2364.78±956.35 meters at 1.33±0.25 meters/second with 242.61 ±80.31 stops and starts in 29.98±11.79 minutes of play per game. The wheelchair basketball athletes averaged 2679.52+1103.66 meters traveled at 1.48+0.13 meters/second with 239.78±60.61 stops and starts in 30.28+9.59 minutes of play per game, over two games [49].

In community based studies done with MDL‘s, Tolerico et al (2007) reported that veterans in their everyday wheelchairs traveled 2456.95 ± 1195.73 meters per day at a speed of 0.79 ± 0.19 meters/second. The rugby participants in this study traveled almost the same distance and the basketball athletes traveled farther in roughly an hour of game play. The MDLs have recently been used to collect data from hand-cycling during the National Veterans Wheelchair Games, and the data are currently being analyzed.

The implication of the study conducted by Sporner, Grindle, Cooper et al. (2009) is that everyday propulsion is not likely to adequately prepare a player for competition; therefore appropriate training techniques need to be further developed and implemented. Using MDLs during game play and during practices may provide increased opportunities to players.

2.11 PARALYMPIC RESEARCH NEEDS RELATED TO WHEELED SPORTS

There are a number of areas that need greater scientific evidence in order to improve sports performance, promote health and safety during training and competition, and to help ensure fair and equitable competition. Some of our observations from working with elite athletes and in reviewing the literature suggest future research areas that would benefit the Paralympic Movement [50-54].

It is only natural and in some cases necessary for athletes at the elite level to push their minds and bodies to their physical limits. This becomes more apparent as the competition achieves higher performance levels, and as there is more national and international attention drawn to Paralympic sporting competitions. It is clear that a growing number of countries are investing greater resources in order to increase their medal count within the quadrennial Paralympic Games as a matter of national pride and equality for their citizenry. This has started to reveal at least three factors for further study: (1) with athletes training at higher levels of duration and intensity there is a concomitant increased risk for injury, especially if training programs are not optimized to individual capabilities; (2) with greater issues, such as national pride at stake, there is a growing risk for liberal interpretation of the classification system for the sake of winning medals at the cost of excluding some extremely talented athletes and the overall goals of the Paralympic Movement; and (3) technological advances, while mostly having a positive effect, have given rise to "techno doping" where technical standards and the training of technical officials may not be keeping pace with technological advances.

Research related to the Paralympic Movement needs to take a two-prong approach. There needs to be systems or organizational level research to determine how best to achieve the goals of the Paralympic Movement, and there needs to be sports specific research and development.

The systems wide research agenda needs to include such activities as training and certification of international officials, especially in Paralympic specific domains like technical officials. Our observations and experiences indicate, for example, that there are too few technically or engineering trained officials participating in technical rule making, and enforcing technical rules. This appears to have led to some inequities in competitions based upon disparate rule interpretations and enforcement. Further, the research supporting classification is very limited, and recent studies have shown significant short comings in upper body strength and balance measurement among people with disabilities [55, 56]. For example, although not yet scientifically investigated, there are concerns among elite hand-cycling athletes that individuals with trunk musculature sufficient to use a kneeling hand-cycle have a significant advantage over athletes who must use a recumbent hand-cycle due to their physical limitations to attain maximal personal performance. A preponderance of the medals awarded to male hand-cycling athletes in the 2008 Paralympic Games went to individuals using kneeling hand-cycles. There also needs to be study of the appropriate number and mix of medical and therapeutic staff that should be available to support individual teams and international competitions, as well as the role of sports medicine professionals in the preparation of athletes and health maintenance of Paralympic athletes. Too many athletes participating in elite competitions have or develop pressure ulcers or stump wounds that hinder performance and preparatory work. Data from the 2008 U.S. Paralympic team indicate that boat work in rowing/sailing had a higher incidence of pressure related injuries, but athletes in wheeled sports and athletics were also affected. Equestrian athletes could use custom saddles to provide support and to reduce spasticity. More credentialed staff may be needed to manage health issues, especially as they impact performance. Coaches and athletes need more pressure ulcer and skin care education. Athletes should have regular physical/medical evaluations to build confidence to reduce risk of trying to hide health issues. Pressure ulcer prevention needs to include toilets, tubs, transport, as well as sports equipment. From a systems-wide perspective, obtaining information related to doping control certificates from the International Governing Bodies needs to be improved. There also needs to be more grass-roots sports and recreation opportunities are needed to increase the pipe-line of elite athletes.

As for wheeled mobility sports research and development, there are a wide variety of needs. We have focused on those for developing elite athletes for international and Paralympic Games competitions. For wheeled mobility sports, performance and coaching could be improved through the development and application of wireless data-logging to look at key factors of speed, acceleration, distance, and placement on the court relative to other players, starts-stops during scrimmages and possibly during games, races, and matches. Some teams currently use a simple approach of placing one coach high in the stands, who is in communication with the coach on the sidelines. This provides both qualitative and interpretive data, which could be augmented with quantitative data.

Adaptations to the SMART^{Wheel} technology used for wheelchair fitting, and propulsion research, may be useful in optimizing sports propulsion, wheelchair sports fundamental skills, and for fitting sports wheelchairs to individual athletes [57, 58]. The current SMART^{Wheel} technology may be used for investigating tennis, rugby and basketball skills.

In court sports, some teams develop and exploit a speed advantage [59]. This is likely due to coaching, training, and better fitting between the wheelchair and the user. Sometimes this can be overcome with effective substitution of fresh players and a strong defense. As more athletes with complex seating needs evolve into elite athletes, properly addressing their seating needs becomes critical. For example, rugby players with multiple limb amputations are becoming more common; however, when they have very short trans-femoral residual limbs balance and ball control can become quite challenging. Hand-cycling is another sport where seating appears to be key. Although the evidence is currently anecdotal, it appears that there are significant advantages to the kneeling sitting style versus the recumbent style for many types of courses. This needs further study, and investigation of possible means of optimizing seating to ameliorate the relative advantages. Rugby wheelchairs have evolved to be quite heavy, in excess of 15 kg, in order to withstand the impacts imparted during training and games. Much of the weight has come from adding bracing and gussets in order to strengthen high-stress areas based upon experiential and observational data. While this approach has resulted in fewer failures to rugby chair frames, it is far from optimal in maximizing the strength to weight ratio resulting in a rugby chair that has sufficient strength while being as light as possible. Light weight is essential for maximizing acceleration, optimizing maneuverability, and minimizing stress on the upper limbs. Some consideration should be given to applying other materials, and different design approaches such as using large diameter tubing (e.g., greater than 50 mm in diameter versus 20 mm in diameter).

Much work is needed in designing throwing chairs. Technology has not changed much since the early 1990‘s. Individual biomechanical analysis of throwing is needed to guide both technology design and to improve technique. Some knowledge from seating may help to guide the way, such as locking the legs/pelvis to provide a base of support for the origins and insertions of active muscles and to reduce extraneous motions of impaired body parts. The back must have freedom to move, whilst at the same time being adequately supported. Appropriate seating for throwing and promote a complete follow-through, for example with the use of straps to prevent falling. Investigation is needed to optimize leg position. The pole of the throwing chair should be tuned for the thrower. Some are wood, others fiberglass, and still others steel. Athletes should consider specializing within the Field-Events.

To address the issues of pressure sores, extensive seating research and development needs to focus on device/body interface conditions which take into account the high interface loads which occur during propulsion (e.g. in wheelchair racing) or by strapping the athlete into the wheelchair (e.g. in tennis), as well as the reduced interface surface area that may occur in the unique postural positions in some sports wheelchairs. Athletes sitting in the position with their knees higher than their hips have higher risks of developing pressure sores underneath the sacrum (tail bones) because this sitting position shifts body weight backward [60-62]. Under these conditions, traditional seating systems have not been entirely successful at preventing pressure sores.

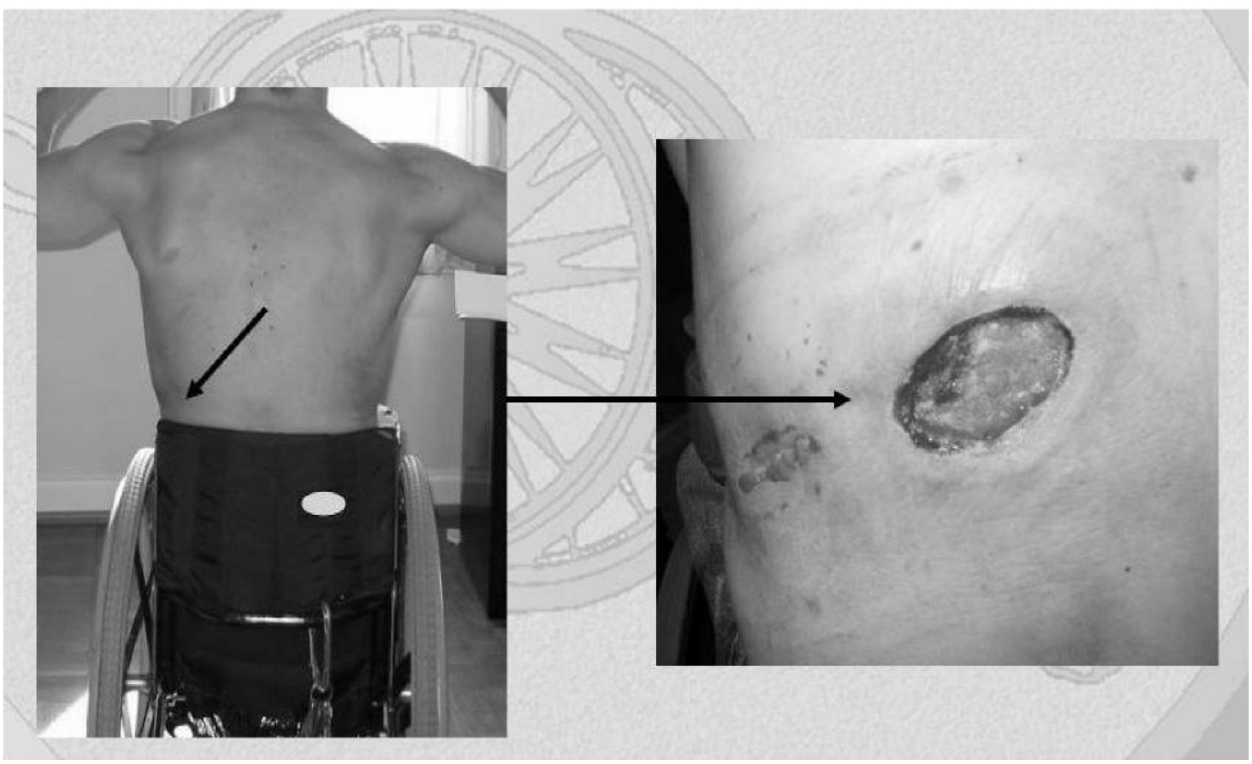

Figure 9. Skin breakdown due to improper adaptive seating. Stage I ulcer from a ski (left) and Stage 3 ulcer from a rigid racing chair shell (right).

Mimicking the design approach of prosthetic sockets and ski-boots, a more complete description of the shape of the athletes‘ body where it interfaces the sports device (e.g. using laser scanning techniques) could be used to develop highly conforming and pressure-relieving seating systems.

2.12 SUMMARY

Adaptive sport continues to break down social, conceptual, and physical barriers. Athletes with disabilities are narrowing the gap in competition between the impaired and the unimpaired through the advancement of technology, and the competitive spirit and ingenuity of the seated athlete. Consideration should always be given to proper equipment selection, maintenance, and fitting in order to maximize functional capacity, improve performance and prevent injury. Future research will require the expertise and coordinated effort of multiple disciplines. Further study should include; (1) Performance enhancement by identifying ways to optimize training and provide sound coaching at all levels; (2) Improving equipment design to provide superior strength whilst decreasing weight and increasing maneuverability ; and (3) Providing protection from repetitive trauma which could lead to pressure sores and various other injuries.

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3.0 INVESTIGATION OF THE IMPACT OF SPORTS, EXERCISE AND RECREATION (SER) PARTICIPATION ON PSYCHOSOCIAL OUTCOMES IN A POPULATION OF VETERANS WITH DISABILITIES. A CROSS-SECTIONAL STUDY.

Sport, exercise and recreation (SER) are important tools for health, fitness and social change, as well as for rehabilitation in individuals without disabilities. Over the past two decades studies regarding the effects of SER have been focused on able-bodied individuals. The beneficial effects of SER on physical health and psychosocial well-being in this population has been researched extensively and well established in the literature [1-9].

3.1 HISTORY OF ADAPTIVE SPORT

Just as participation in SER may have physical and psychosocial benefits for those without disabilities; it stands to reason that participation in such activities may benefit individuals with disabilities as well. Shortly after World War II, Sir Ludwig Guttmann and his colleagues at Stoke Mandeville Hospital in England needed exercise and recreational outlets for the large number of young people recently injured in the war [10]. Out of this need came wheelchair sports as a rehabilitation tool. News of Dr. Guttmann‘s success in rehabilitating his patients by means of sports spread through Europe and to the United States. In 1948, he organized Games for British veterans with disabilities. In 1952, these Games developed into the first international wheelchair sporting competition for people with physical disabilities. The year 1960, marked the first international games for individuals with disabilities that were held in conjunction with the Olympic Games in Rome. The name Paralympics was coined during the 1964 Tokyo games, and to this day, this elite international competition among individuals with disabilities occurs following the Olympics [10]. Since then hundreds of non-profit and community based programs have emerged to offer adaptive sport and recreation. Some rehabilitation hospitals have spent considerable amounts of money to incorporate sport and recreation into their treatment programs. The movement of sport and recreation as rehabilitation has developed despite the lack of a strong foundation of scientific evidence substantiating the positive outcomes of SER for individuals with disabilities. Due to a lack of scientific support, these programs are often the first to be cut when funding becomes an issue.

Evidence to support the benefits of SER as rehabilitation is needed more at this time in history than perhaps ever before as the number of United States veterans living with some type of disability has reached 5.5 million more than doubling the number of veterans with disabilities in 2001 [11]. The main reasons for this increase are an aging veteran population and an influx of injured service members from the most current conflicts, Operation Enduring Freedom (OEF) in Afghanistan and Operation Iraqi Freedom (OIF) in Iraq. Service members are surviving injuries that would have been fatal in past conflicts due to advances in protective equipment and battlefield care [12]. It is estimated that for every service member killed in combat, there are at least sixteen wounded, many of who will return with some type of disability [13]. In addition to an increased number of veterans with physical disabilities, the number of service members with mental health diagnoses is also increasing. A 2007 study conducted by Seal et al reported that over 30,000 of approximately 100,000 OEF/OIF veterans studied received a mental health or psychosocial diagnosis and 56% of these veterans have received more than one diagnosis [14]. With such a drastic increase in the number of veterans who are living with these issues, it is important to identify interventions to assist in their recovery process.

The detrimental effects of disability on psychosocial well-being have been documented in the literature [15-23]. Psychosocial well-being has been defined by such constructs as mood, trait anxiety, self-esteem, perceived competence and quality of life (QOL). These constructs have been validated in studies involving individuals with a variety of disabilities [24-26]. When faced with the reality of a disability, many individuals experience negative feelings including but not limited to; decreased self-esteem, depression, feelings of hopelessness, and reduction in overall QOL [19-2 1]. Since psychosocial well-being is a complex multifocal construct we decided to investigate the concepts of self-esteem and QOL in this study due to their relationship to successful rehabilitation outcomes and close relationship to acceptance of disability [27]. Decreased self-esteem and reduction in overall QOL have been correlated with disabilities of varying etiology and severity [19, 20]. These are significant issues and have been associated with unemployment, decreased community re-integration, poor physical health and overall decreased function [19-23].

3.1.1 Self-esteem

According to Branden, self-esteem is the sum of self-confidence (a feeling of personal capacity) and self-respect (a feeling of personal worth). It exists as a consequence of the implicit judgment that every person has the ability to face life's challenges, understand and solve problems, and the right to achieve happiness, or to respect and defend their own interests and needs [28]. There is a true sense of accomplishment and personal well-being that comes from being able to navigate challenges or attain personal goals. Inability to set and meet goals can lead to lower levels of community integration and decreased overall function; because individuals with reduced self-esteem may withdraw from situations they feel incapable of managing. Conversely success leads to increased confidence and greater willingness to set new goals [29-31]. Moreover, a skewed perception of personal capabilities brought on by low self-esteem may be more limiting than the disability. This is particularly important in veterans and service members. Many persons who have served in the military put a high value on physical prowess and their ability to handle difficult and stressful situations. For this reason, veterans with traumatic and acquired disabilities are at increased risk for decreased self-esteem due to alterations in self perception related to traumatic and acquired disability. It has been suggested that SER may provide an effective mode through which self-esteem can be enhanced based on its ability to provide the individual with a meaningful mastery experience as well as positive interactions with others and an improved perception of physical self [32].

3.1.2 Quality of life

Quality of life scores reflect the adjustment of people with disabilities and show their overall satisfaction with life [33]. According to a study by Rimmer et al many people with physical disabilities, in addition to having poor general health and limited community participation, also report poor QOL [34]. Kannisto et al reported that individuals with SCI reported QOL scores

10% below those recorded for able-bodied adults [35]. Quality of life has been defined by the World Health Organization as the individual‘s perception of their position in life, in the context of culture and value systems in which they live and relation to their goals, expectations, standards and concern [36]. This definition provides an important concept related to our population. The military is truly its own culture and therefore may have distinctly different responses to SER.

In 2009, Sporner et al reported that 98% of veterans stated that participated in the National Disabled Veterans Winter Sports Clinic (NDVWSC) and National Disabled Veterans Summer Sports Clinic (NDVSSC) had improved their QOL. Increased relationships with friends and the ability to be competitive were two areas where study participants said that the NDVWSC and NVWG had influenced their lives. Participants at these events also scored high (34.3+5.5 out of a possibly 40) on a measure of self-esteem [37]. McVeigh et al found that individuals with a spinal cord injury (SCI) who participated in sports were 7 times more likely to report higher QOL scores than those who did not participate in sports [38]. A recent study on athletes with cerebral palsy (CP) found that the majority of the athletes either agreed or strongly agreed that adaptive sport positively influenced their overall health (85%), QOL (81%), quality of family life (53%) and quality of social life (56%) [39].

While studies have been conducted in this field there is still a significant gap between research on the effects of SER in able-bodied populations and those with disabilities. Many of the studies related to individual with disabilities have small sample sizes, methodological problems or both. As there are limited studies related to the effects of SER on individuals with disabilities there are fewer still related to service members and veterans.

3.2 METHODS

3.2.1 Structure/Content

The study consisted of a one-time questionnaire composed of 5 sections with questions related to demographics (I), medical information (II), assistive technology use (III), sports participation (IV) and standard measures of self-esteem, and QOL.

3.2.2 Demographic Variables

Demographic data collected included age, gender, and ethnic origin. General military information requested included veteran status and rank (either currently or at time of discharge if the participant was separated from the service). The demographic section also included information concerning marital and employment status, as well as education level.

3.2.3 Medical Information and Assistive Technology

The second section asked the participants to report information regarding their disability and current health status. Data were collected on disability type, level and duration. This section also investigated possible concomitant injuries and/ or disease processes. The third section presented questions related to use of assistive technology devices.

3.2.4 Standardized Questionnaires

The final section of the questionnaire presented the Rosenberg Self-Esteem scale (RSE) and the World Health Organization Quality of Life - Brief (WHOQOL BREF) The RSE is a reliable measure consisting of ten statements that ask level of agreement (4-point Likert scale) [40]. A total score is calculated, with a higher score indicating better self-esteem. Quality of life was assessed by using portions of the WHOQOL-BREF. The WHOQOL-BREF is a 26 item self- report questionnaire. 24 items constitute four sub-domains: physical health, psychological health, social relationships, and environment, where as the other two items, measure overall QOL and general health [41].

3.2.5 Participants and Data Collection

Participants were recruited in 2009 and 2010 from registered athletes at the National Veterans Wheelchair Games (NVWG), the United States Olympic Committee Warrior Games (WG) and the National Veterans Summer Sports Clinic (NVSSC). All participants were active duty service members or veterans of all branches of the United States Armed Forces who currently have some type of disability. Potential participants approached the designated research area at the events, indicated an interest in participating and were provided an opportunity to read an informational sheet with the essential elements of informed consent and provided verbal consent. Individuals were only excluded if they were unable to complete the questionnaires or presented with severe traumatic brain injury (TBI). While severe TBI was an exclusion criteria there was no differentiation made between mild and moderate TBI. No exclusion criteria were based on race, ethnicity, gender, or HIV status. This study was approved through the VA Pittsburgh Healthcare System Institutional Review Board (#02954).

3.2.6 Statistical methods

Our descriptive analysis examined demographics and medical history. Bivariate correlation analysis was conducted using the spearman rho correlation coefficient to investigate the possible association between the number of years the individual participated in SER since the onset of their disability and their self reported QOL.

The effect of the specific event on self-esteem scores was analyzed independently using a one-way between subjects analysis of variance (BS ANOVA). To analyze the effects of the years of participation in SER since disability and the type of activity that the participant engaged in on self-esteem scores, a 3x4 BS ANOVA was conducted. The variable of years of participation in SER since onset of disability was separated into four groups; less than one year, one to five years, five to ten years, and more than ten years. The variable of the type of activity the participant engaged in was separated into individual sports/ events, team sports/ events and a combination of individual and team sports/ events. For example if a participant only participated in swimming they would placed in the individual group, similarly if they only played wheelchair basketball they would be placed in the team group, if the individual participated in both they would be in the combination group. Post-hoc testing was conducted using Scheffe's procedure. The Scheffe test was selected due to the fact that it is flexible, conservative, can be used with unequal groups and like ANOVA is robust with respect to non-normality and heterogeneity of variance. Findings are presented separately by event for demographic and medical data. In order to investigate the effect of years of participation and activity type on self-esteem independent of event group affiliation all data were combined and analyzed using the 3x4 ANOVA.

3.3 RESULTS

3.3.1 Participant Demographics

A convenience sample of 220 sports participants over the age of 18 and registered athletes at the WG, the NVWG, and the NVSSC were recruited. The total group included 190 males and 30 females. The average age of the sample was [avg + std dev] with a range from 23-76 years of age. Ninety-eight individuals were enrolled at the WG and the mean age of study participants was 31 (+7.3, range 21 to 54) years. Seventy athletes from the NVWG with a mean age of 52.3 (+9.67, range 32 to 69) were enrolled in this study. Fifty-two individuals from the NVSSC were enrolled. The mean age of participants was 40.4 (+12.3, range 26 to 65) years. All athletes at the NVWG and NVSSC were veterans, while only 39% of the participants at the WG were veterans. Participants in each group were predominantly Caucasian (60% WG, 68% NVWG and 50% NVSSC). Additional demographic information of the study sample from each event, including highest level of education achieved, marital status and employment status are presented in Table 1.

Table 1. Participant demographics

Where percentages do not equal 100 participants did not respond

		WG (*n*=98) % (*n*)	NVWG (*n*=70) % (*n*)	NVSSC (*n*=52) % (*n*)
Gender	Female	10 (10)	17 (12)	15 (8)
	Male	90 (88)	83 (58)	85 (44)
Ethnicity	Caucasian	60.0 (59)	69.0 (48)	50.0 (26)
	Hispanic or Latino	16.0 (16)	6.0 (4)	21.0 (11)
	Black/African American	10.0 (10)	17.0 (12)	12.0 (6)
	Two or more races	n/a	7.0 (5)	8.0 (4)
	American Indian or Alaskan Native	n/a	1.0 (1)	n/a
Military status	Active Duty	61.0 (60)	0	0
	Veteran	39.0 (38)	100.0 (70)	100.0 (52)
Educational level	High school diploma or GED	48.0 (47)	40.0 (28)	44.0 (23)
	Higher education (Associate's - Doctorate)	45.0 (44)	59.0 (41)	46.0 (24)
Marital status	Married	47.0 (46)	37.0 (26)	31.0 (16)
	Single	34.0 (33)	6.0 (4)	25.0 (13)
	Divorced/Separated	12.0 (12)	39.0 (27)	40.0 (21)
	Widowed	n/a	3.0 (2)	4.0 (2)
Occupational status	Employed	77.0 (75)	13.0 (9)	0 (0)
	Unemployed (disability,by choice, unable to find a job)	3.0 (3)	39.0 (27)	42.0 (22)
	Retired	5.0 (5)	36.0 (25)	19.0 (10)
	Student	10.0 (10)	n/a	19.0 (10)
	Other	n/a	1.0 (1)	15.0 (8)

3.3.2 Medical History

Four primary disabilities, traumatic brain injury, spinal cord injury, post-traumatic stress disorder (PTSD) and upper or lower limb amputations were represented in the three groups of athletes (see Table 2). Additional diagnoses including, but not limited to, arthritis, digestive problems, heart trouble and diabetes were also indicated by a majority of participants across all three groups. Comorbid conditions were reported by 64% of participants at the WG, 79% of participants at the NVWG and 65% of NVSSC participants. It is important o remember that each participant may have more than one disabling condition.

Table 2. Four primary participant disability conditions

Disability	**WG (*n*=98) % (*n*)**	**NVWG (*n*=70) % (*n*)**	**NVSSC (*n*=52) % (*n*)**
TBI	46.0 (45)	16.0 (11)	75.0 (39)
Spinal Cord Injury	12.0 (12)	70.0 (49)	27.0 (14)
PTSD	23.0 (23)	16.0 (11)	19.0 (10)
Amputation	22.0 (22)	11.0 (8)	17.0 (9)
Other	2.0 (2)	10.0 (7)	8.0 (4)

3.3.3 Quality of Life

There was a positive relationship between the individuals QOL and the number of years they spent participating in sports and recreation since their disability, $r_s = .40$, $p<.001$. It should be noted that due to the wide variety of disabilities represented in this study scores were not analyzed with regard to disability level. However scores were examined based on the number of concurrent conditions the participant had (1 diagnosis, 2 diagnoses, or 3 or more diagnoses) and no significance was found $p=.074$.

3.3.4 Self-esteem

A one-way between-subjects analysis of variance (ANOVA) was performed on self-esteem scores as a function of the event participated in (WG, NVWG or NVSSC). The assumption of homogeneity of variance was met, Brown-Forsythe $F(2, 215) = 1.427$, $p = .242$. The assumption of normality was not met for the WG or the NVWG (Table 2). All other assumptions were met. Due to the violations of the assumption of normality parametric and nonparametric statistical analyses were run on all available data. Both parametric and nonparametric tests produced similar significant results suggesting that the one-way ANOVA was robust against the violation of normality, as such parametric results will be reported for this section.

There was a significant difference on the self-esteem scores when analyzed by event (WG, NVWG, NVSSC), $F(2, 215) = 3.951$, $p = .021$, partial $\eta2 = .035$ (Figure 10). In order to find the pattern of differences on self-esteem scores among the levels event participation post-hoc pairwise comparisons were conducted using the Scheffe adjustment. Individuals who participated in NVWG (M=23.783, SE=.656) had significantly higher self-esteem scores than those who participated in NVSSC events (M=21 .120, SE=.770), p=.033. There were no significant differenfound between the WG (M=23.394, SE=.547) and the NVWG (M=23.783, SE=.656), p=.902 or between the WG (M=23.394, SE=.547) and the NVSSC (M=21.120, SE=.770), p=.057 however the result is trending toward significance.

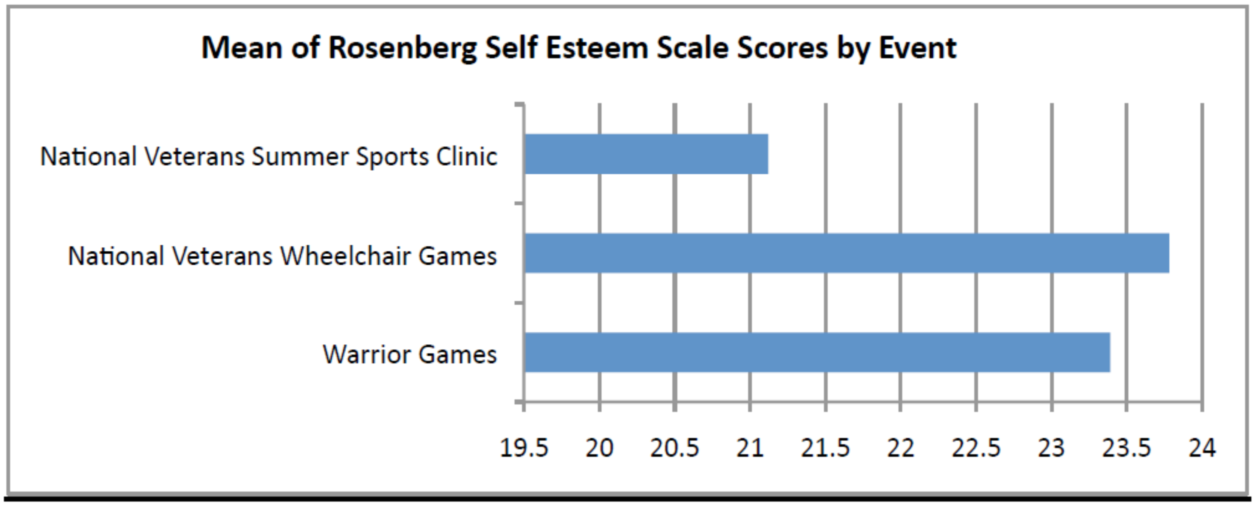

Figure 10. Self-esteem scores analyzed by event.

A 3 × 4 between-subjects analysis of variance was performed on self-esteem scores as a function of type of activity engaged in (Individual sport/ recreation events, team sport/ recreation events, or a combination of the two) and years of participation in SER since the onset of disability (less than 1 year, 1 to 5 years, 5 to 10 years, and more than 10 years). The assumption of homogeneity of variance was violated, Brown-Forsythe F (11, 199) = 2.588, p = .041. The assumption of normality was met for all but three groups (Table 3).

All other assumptions were met. Due to the violations of the assumptions of normality and homogeneity of variance parametric and nonparametric statistical analyses were run on all available data. Both parametric and nonparametric tests produced similar significant results suggesting that the 3x4 ANOVA was robust against the violations; as such parametric results will be reported for this section.

There was a significant difference on the self-esteem scores among the levels of years of participation since onset of disability averaged across the type of activity engaged in, $F(3, 211) = 7.20$, $p < .001$, partial $\eta^2 = .098$. There were also significant differences found on the self-esteem scores among the levels of type of activity engaged in averaged across the levels of years of participation since onset of disability, $F(2, 211) = 4.698$, $p = .010$, partial $\eta^2 = .045$.

In order to find the pattern of differences on self-esteem scores among the levels of years of participation since onset of disability post-hoc pairwise comparisons were conducted using the Scheffe adjustment. Individuals with more than 10 years of participation in SER since onset of disability (M=26.56, SE=1 .083) had significantly higher self-esteem scores than those with 1 to 5 years (M=22.62, SE=.626), p=.001 and those with less than 1 year (M=21 .35, SE=.644), p<.001. Also those with 5 to 10 years (M= 25.65, SE=.686) of participation in SER since onset of disability had significantly higher self-esteem scores than those with less than 1 year (M=21.35, SE=.644), p=.020. There were no significant differences found between 5 to 10 years of participation and 1 to 5 years of participation or between 5 to 10 years of participation and more than 10 years of participation (Figure 11).

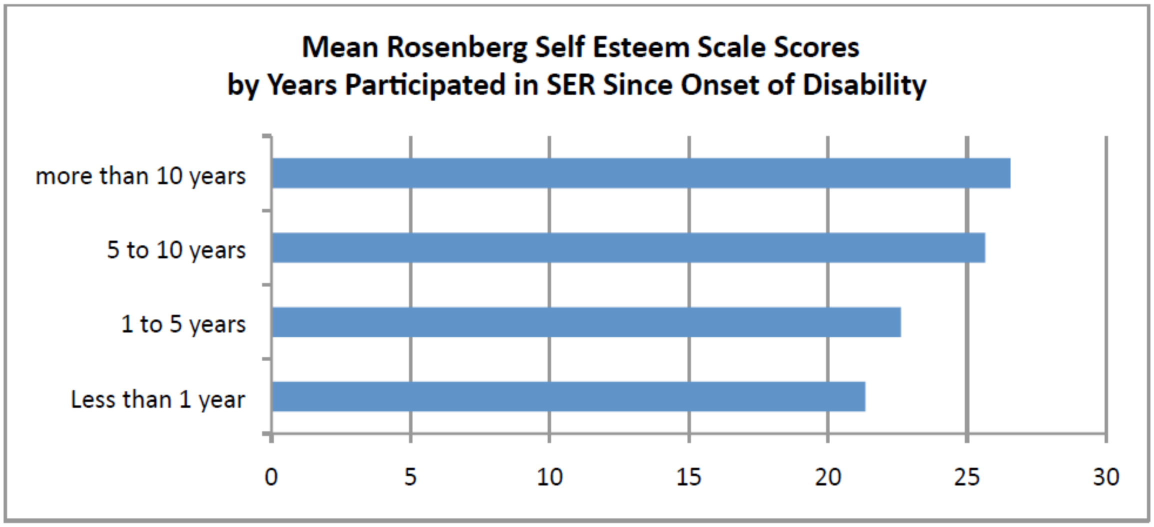

Figure 11. Self-esteem scores analyzed by years of participation in SER since onset of disability.

In order to find the pattern of differences on self-esteem scores among the levels of type of activity engaged in post-hoc pairwise comparisons were conducted using the Scheffe adjustment. Individuals who participated in primarily individual sporting and recreation events (M=21.69, SE=1 .083) had significantly lower self-esteem scores than those who participated in either primarily team events (M=24.28, SE=.999), p=.037 or a combination of team and individual events (M=23.71, SE=.682), p<.036. There were no significant differences found between the team and combination groups (Figure 12).

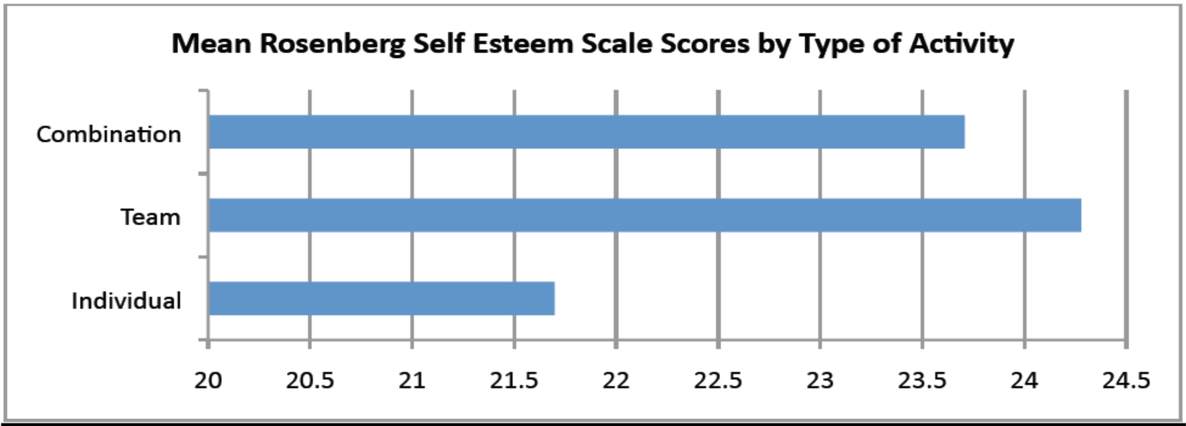

Figure 12. Self-esteem scores analyzed by type of activity participated in.

The pattern of differences on the self-esteem scores among years of participation in SER since onset of disability were not significantly different between the levels of type of activity engaged in, F (6, 211) = 1.152, p = .333, partial η2 = .034 (Figure 13).

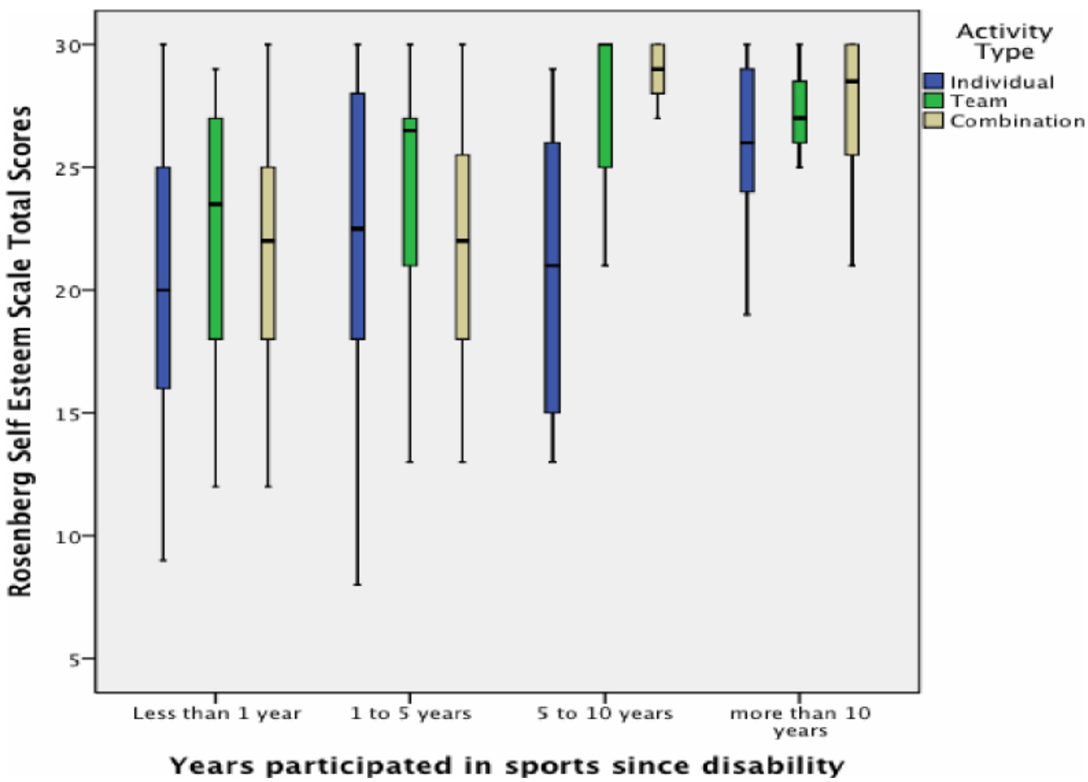

Figure 13. Self-esteem scores as an effect of activity type and years of participation in SER since onset of disability.

3.4 DISCUSSION

Fueled by clinical evidence and testimonials provided by patients, athletes, and medical providers, SER has been used to augment rehabilitation programs for decades. While there have been many stories of positive life changing experiences related to involvement in adaptive SER there is a paucity of strong scientific evidence to support these claims. Proponents of sport and recreation as rehabilitation cite increases in self-esteem and overall QOL as possible positive outcomes related to participation in SER for both the able-bodied and disabled populations. This study has attempted to bridge some of the gap between belief and evidence with regard to possible psychosocial benefits resulting from participation in adaptive SER.

Self-esteem, is a global measure of an individual's assessment of self-worth, is strongly affected by perceptions of competence. Self-esteem is related to the belief that one possesses the necessary skills to complete a task as well as confidence that the task can actually be completed and the desired outcome obtained. Sport, exercise and recreation have long been suggested as an effective mode through which self-esteem can be enhanced based on the ability to provide the individual with a meaningful mastery experience. In addition, participation in sports can foster positive interactions with others and an improved perception of physical self [42].

While the three national rehabilitation events where data were collected hold some similarities, there are also some significant differences between them. The NVWG has been held every year for over 30 years and attracts over 500 athletes from across the United States, Great Britain and Puerto Rico. The NVSSC and WG are much younger and smaller events. The

NVSSC has been held for the past 5 years, only allows participation by individuals who sustained an injury within the past 6 years and hosts around 100 athletes. The WG are hosted by the United States Olympic Committee, have only been held for the past 2 years, and the number of participants is limited to roughly 50 per branch of the military, for a total of just over 200 athletes. The NVSSC is set-up as a learning through experience clinic while the NVWG and WG are both competitive events. The energy for the two latter events is high, even tense at points, depending on the sporting event.

Self-esteem scores were significantly higher among participants at the NVWG than those at the NVSSC. No significant differences were found between the NVWG and the WG or between the WG and the NVSSC. Several attributes related to the populations of participants at the events as well as the attitude of the events themselves may help to explain these differences.

Participants at the NVSSC are closer to their onset of injury/disability than those at the NVWG and have less experience participating in adaptive SER. The concept of identity erosion vs. identity renewal, proposed by Graham et al, suggests that individuals with acquired disabilities have an initial sense of loss, or erosion, of identity, whether physical, emotional or occupational. Over time, through participation in SER, individuals who participate in SER may be able to cultivate a new athletic' identity that fosters competence and allows for a continuity of core aspects of self [43]. This takes time to develop and helps to explain the findings of higher self- esteem scores related to more years of participation in SER.

Additionally, the characteristics of the events may play a role in how they boost the self-esteem of the individual participant. The WG and the NVWG are aimed at competition versus training in a new sport. Although not conclusive, studies have suggested that higher intensity activities are more effective than activities of low intensity [44]. As competition becomes more heated individuals tend to fight through pain and produce compensations allowing them to accomplish tasks, which may have previously seemed impossible. Also, a high number of the participants at the WG are still on active military duty, either going through rehabilitation or having already returned to their unit. An intense focus on esprit de corps and service camaraderie is present at the WG since the participants are separated into their respective parent services (Marine Corps, Army, Navy/ Coast Guard, Air Force, and Special Operations). In addition to the coveted bragging rights among the services, the group dynamic stressed in this event could lead to higher levels of self-esteem.

Group dynamics fostered by the event itself as well as by the competitive teams to which an individual athlete belongs may influence self-esteem. Support from one‘s peer group has been reported as the strongest source of social support, and self-esteem is also strongly associated with emotional responses [45,46]. Athletes at each of these events may participate in individual events, team events or a combination of both. Significant differences in self-esteem were found when those who participated in individual events were compared with both team events and a combination of events. Athletes who participated in individual events alone consistently had lower self-esteem scores. Members of a team may look at a task as less daunting and therefore easier to reach their desired goals. Of note, athletes who participated in individual sports did not meet criteria for low self-esteem, but scored lower than those who participated in team sports.

Burke et al found that participation in SER in a well formed true group' offers the greatest benefits [47]. Zander suggests that well formed groups are invested in the achievements of the collective, converse freely, assist and receive advice from one another, identify the collective as we‘ and non-members as they‘. The mindset of the military is encapsulated perfectly in this description. Furthermore, observations have shown that team cohesion forms more quickly between service members and veterans than is found with civilians [48]. The environment created by being surrounded by a group of your peers or your team may provide an internal support system that helps to foster positive self-esteem. As a result, athletes at these events who participate in team events or a combination of events that includes team play would have significantly higher self-esteem scores than the individual group.

The literature has consistently reported a link between physical activity and higher quality of life among various populations including individuals with chronic illnesses or various disabilities [49-54]. Unfortunately most published research studies are unable to establish causality because of cross-sectional study design and a small number of participants. Causality cannot be inferred in the present study because of the cross-sectional design. A strong, positive correlation was found between the number of years an individual has participated in SER since the onset of disability and their level of self reported QOL. This relationship was independent of event participation or the type of activity that was engaged in by the individuals. Scores were not analyzed based on severity of disability, however, the number of concurrent diagnoses of the participants was accounted for and no significant effects were found. The lack of significant findings related to QOL could be due to the way rehabilitation is conducted at the VA/DoD. In these facilities, self-selection is not as much of an issue as it is in the civilian world as everyone eligible to participate is highly encouraged‘ to do so or even pursued by medical personnel that believe in the power of SER. Individuals with a higher severity of injury or those seen as higher risk for functional or emotional deterioration may be approached more vigorously in an attempt to get them involved.

3.5 CONCLUSION

Sport, exercise and recreation have been used as formal rehabilitation for over 60 years and informally for as long as there has been sport. A paucity of evidence exists, however, related to the health and psychosocial benefits of sport in the disabled population. This study attempts to support the widely held belief that recreation as rehabilitation holds psychosocial benefits for individuals with disabilities. Overall, the results from this study support a positive relationship between sports and recreation and increases in self-esteem and improved quality of life.

Several limitations to this study must be noted. First, the cross-sectional design of this study means that positive longitudinal effects of the participation in these sporting events cannot be determined. Second, there was no control group against which results could be compared. Level and severity of disability was also not taken into account during the analysis due to the wide variety of physical and cognitive disabilities present in the study population leading to disagreement of level of severity between the two. Finally, this was a convenience sample with no randomization of participants.

This study provides a solid step forward in investigating the potential multidimensional benefits of participation in sport and recreation in a disabled population, but there is still much work to be done. Future research needs to address further potential benefits both health and psychosocial. Studies should also focus on longitudinal outcomes, with baseline measures and functional control groups in order to evaluate the possible predictive and/ or causal relationship between sport and recreation.

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4.0 INVESTIGATION OF THE IMPACT OF SPORTS, EXERCISE AND RECREATION (SER) PARTICIPATION ON PSYCHOSOCIAL OUTCOMES IN A POPULATION OF VETERANS WITH DISABILITIES USING THE SPORTS OUTCOME RESEARCH TOOL AND COMPREHENSIVE UNIFORM SURVEY (SPORTACUS). A LONGITUDINAL STUDY.

The number of individuals living with some type of disability is increasing at an accelerating rate. The World Bank estimates that approximately 600 million people or 10% of the world's population have a disability [1]. According to the Bureau of the Census, more than 49 million individuals with disabilities reside in the United States alone, making this population the third largest minority in the country [2]. Unfortunately, this number is on the rise due to issues such as an aging population, natural disasters and the current wars in Iraq and Afghanistan.

4.1 INDIVIDUALS WITH DISABILITIES

4.1.1 Veterans

Since September 2001, over 2 million service members have served tours of duty in Afghanistan and Iraq [3]. Survival rates for these conflicts have increased drastically due to improvements in battlefield care and protective equipment. Wounds that would have proven fatal in the past are now resulting in a number of physically and psychologically disabling conditions [4]. Combat related injuries are recognized as an unfortunate by-product of war and are accounted for in the overall healthcare budget. However, the number of service members returning with disabilities from the current conflicts has been significantly underestimated. In 2008, Stiglitz and Blimes projected that between 366,000 and 398,000 veterans from these wars would have filed for disability claims by this point. In fact, more than 553,000 have already applied for VA disability compensation by February 2011 [5]. The addition of a population of aging veterans from past conflicts with acquired disabilities increases the total number of veterans in the United States living with some type of disability to approximately 5.5 million [6]. The federal government has already spent over $31 billion on veterans' medical care and disability benefits since 2001, and the costs of these claims over the next 40 years are expected to range between $355 to $534 billion. The constant influx of new and acquired disabilities has placed considerable stress on an already taxed healthcare system.

While disability rates continue to rise throughout the population, funding, staffing and space for rehabilitation programs is unable to keep pace and patient stays are getting shorter and shorter. The average number of inpatient rehabilitation days decreased from 21 in 1994 to 12 in 2004 [7]. Treatment plans may thus not be as comprehensive as would be considered optimal and patient outcomes can suffer. Medical providers are continually looking for the most effective ways to use their limited resources to provide the best possible care and maximize patient outcomes.

The detrimental effects of disability on psychosocial and physiological well-being have been well documented [8-16]. Physiological deficits related to disability are typically readily apparent and treated, while negative effects related to psychosocial well-being may go unnoticed, even though they are as common and every bit as damaging. Among veterans who utilized VA care, 48% were diagnosed with a mental health problem [17]. Increased depression, decreased self-esteem and reduction in overall quality of life (QOL) have been correlated with disabilities of varying etiology and severity [18-20]. Psychosocial issues can be significant problems in the disabled population and have been associated with unemployment, difficulty with community re-integration, poor physical health and overall decreased function [12-20].

The psychosocial effects of participation in sport, exercise and recreation (SER) have been extensively studied in individuals without disabilities. Reported benefits include, but are not limited to; decreased depression, increased self-esteem, and improvements in overall quality of life [21-28]. In a recent study, Rhodes et al. (2009) note that regular physical exercise is presently considered to be beneficial in the primary and secondary prevention of about 25 disabling conditions [29].

As SER has a wide range of benefits for those without disabilities, it is postulated that participation in SER by individuals with disabilities may yield similar positive effects. While SER for persons with disabilities is not a new concept, its full potential as a powerful, low cost means to foster greater psychosocial well-being for persons with disabilities is only beginning to be realized.

Sport, exercise and recreation have been used to augment rehabilitation programs for decades, fueled by clinical evidence and testimonials provided by patients, adaptive SER participants, and medical providers. While there have been numerous narrative accounts of positive life changing experiences that provide qualitative evidence related to involvement in SER there is a paucity of quantitative research studies measuring clinical efficacy.

Proponents of SER as rehabilitation in able-bodied populations cite decreases in depression and increases in self-esteem, posttraumatic growth and overall QOL as some of the possible positive outcomes. We have selected the following as tenants of psychosocial wellbeing for evaluation in this study: self-esteem, depression, posttraumatic growth and QOL.

4.1.2 Self-Esteem

Self-esteem is a global measure of an individual‘s perception of their self-worth and is thought to be maintained through experiences of success and positive judgments from others [30]. A high self-esteem contributes to a positive attitude toward oneself and toward life in general while low self-esteem stops people from changing their situation, even if they are not very satisfied with it [31]. In the military many training programs, most notably recruit training (or boot camp), are used to influence self-esteem. Initially the individual is torn down, or stripped of their self- esteem and then progressively built back up to an elevated sense of self.

Gains in self-esteem and acceptance of disability have both been found to be psychological indicators of successful rehabilitation for individuals with traumatic disabilities [32-33]. A review of the literature highlighted the following four findings of self-esteem: 1) Self-esteem is strongly affected by perceptions of competence and opinions of significant others**.** 2) Perceptions about physical appearance and social acceptance are strong predictors of self-esteem. 3) Support from one's peer group is the strongest source of social support, with support from family members being almost as important and 4) Self-esteem is strongly associated with emotional responses [34]. SER has been suggested as an effective mode through which self- esteem can be enhanced based on its ability to provide the individual with a meaningful mastery experiences as well as positive interactions with others and an improved perception of physical self [35-36]. As a psychosocial construct, self-esteem is attractive because researchers have conceptualized it as an influential predictor of relevant outcomes, such as academic achievement [37] or exercise behavior [38]. In addition, self-esteem has also been treated as an important outcome due to its close relationship with psychological well-being [39].

4.1.3 Depression

Depression has been ranked as the leading cause of disability in the United States. Over $66 billion is spent each year on lost work productivity and medical treatment related to this illness and veterans account for slightly more than 14% of that total [40-43]. In 1999, a study looking at depression found that 31% of veterans surveyed reported depressive symptoms, which is two to five times higher than found in the general public [44]. Depression is known to be a risk factor for suicide. Risk for suicide in U.S. veterans with depression differs in significant ways from those of the general population. In general, the risk for suicide increases with age, but among the veteran population, younger veterans are at the most risk. [45]. In January 2008, the U.S. Army reported that the rate of suicide among soldiers in 2007 was the highest since the Army started tracking suicide rates in 1980. There were 121 suicides in 2007, a 20% increase over the prior year. National statistics show that veterans constitute about 20% of the 30,000 to 32,000 U.S. deaths each year from suicide. This is an alarming number considering that veterans make up less than 10% of the population. Also, there were approximately a combined 2100 self-injuries and suicide attempts in 2007 [46].

Research studies have suggested that depression is a risk factor for disability and that disability increases the risk of depression [47-50]. Some evidence suggests that individuals with depression have impairments in multiple health related QOL domains similar to those with other chronic conditions such as arthritis, diabetes, and hypertension [51-53]. Long-term depression has been shown to significantly impact cognitive function and depression can even manifest in the form of psychotic symptoms – hallucinations and delusions - similar to schizophrenia [54]. Results from studies have also shown that depressed patients are less fit and have diminished physical work capacity on the order of 80% to 90% of age-predicted norms [55-56]. In the able-bodied population, SER has been shown to alleviate depressive symptoms in clinical and sub-syndromal depression when used as a monotherapy [24-25] and in combination with other treatments for depression [57-58]. Exercise also has the benefit of not having the negative interactive treatment effects, such as those that are potentially encountered when multiple pharmacological agents are employed. Furthermore, exercise is associated with improved QOL among persons with depression and various other chronic medical illnesses [26-27]. When compared with other traditional treatments for depression, exercise was just as beneficial and not significantly different from psychotherapy, pharmacologic therapy, and other behavioral interventions [28].

4.1.4 Post-Traumatic Growth

Tedeschi and Calhoun coined the term posttraumatic growth to describe positive life changes following exposure to trauma [59]. A growing body of literature supports the idea of positive psychological change or growth which occurs as a result of individuals dealing with the stress and life changes associated with adverse life events. Posttraumatic growth is not simply a return to baseline from a period of suffering; instead it is an experience of improvement that, for some individuals, is deeply profound [60].

Various studies have reported on positive changes after diagnosis of, or treatment for, severe illnesses or disability in patients with coronary heart disease, cancer, human immunodeficiency virus, multiple sclerosis, as well as in populations traumatized after traffic accidents, sexual assault, bereavement, natural disasters, or events in a war zone [61-69]. Results seen in people that have experienced posttraumatic growth include some of the following: greater appreciation of life, changed sense of priorities, more intimate relationships, greater sense of personal strength and paths for one‘s life and spiritual development [70].

Posttraumatic growth has been positively associated with social support, active coping, and participation in leisure activities [71-73]. Researchers have begun to investigate the role of leisure in coping with stressful life events, chronic illnesses and disabilities [74-77]. The results of a thematic analysis revealed that leisure influenced at least four aspects of life experiences related to growth: 1) providing opportunities to find personal strengths and abilities, 2) building companionship and meaningful relationships, 3) making sense of traumatic experience and finding meaning in everyday life, and 4) generating positive emotions. Hutchinson et al. (2003) examined how individuals use leisure in coping with a traumatic injury or the onset of a chronic illness. They reported that engaging in personally meaningful and enjoyable leisure activities can be a significant coping source, both immediately following the onset of a traumatic injury and over time [75].

4.1.5 Quality of Life (QOL)

A substantial body of literature supports a link between physical activity and improved quality of life among various populations including the elderly, individuals with chronic illnesses and individuals with a variety of disabilities [78-84]. The longest running longitudinal study that has examined exercise and mental well-being concludes that exercise improves one's ability to enjoy life [84-85]. A review of 14 studies showed a consistently positive association between physical activity level and health-related quality of life [79].

The literature reviewed on QOL related to exercise and disability led to two general conclusions: 1) an alarming rate of physical inactivity is present among older adults, particularly those aging with a disability. 2) Strong evidence exists for the beneficial effects of physical activity on impairment, function, and health-related aspects of QOL among older adults. There is, however, less conclusive evidence for positive effects of physical activity on disability and global QOL [79].

By improving psychosocial well-being, SER may greatly decrease the cost of lifetime care required and improve the long-term prognosis for individuals with disabilities. The history of past wars shows that the cost of caring for combat veterans rises for several decades and peaks approximately 30-40 years after a conflict [4]. Reasons for this peak, which are also present in the civilian population, include progressive functional decline and acquisition of new conditions exacerbated by decreased physical activity. People with disabilities and chronic illnesses tend to be less active due to their physical limitations [86] and a multi-factorial set of barriers [87]. *Healthy People 2020* reported that only 28% of persons with disabilities get the recommended amount of exercise for good health (150 minutes of moderate intensity exercise per week) compared to 47% of individuals without disabilities [88]. A study of individuals with disabilities in Australia concluded that increasing physical activity by 10% would save $258 AUD million dollars in medical related costs. Based on the current pattern of benefit claims and medical usage, the costs for Iraq and Afghanistan veterans over the next 40 years could exceed 700 billion dollars [89]. Developing an evidence base to support the benefits of sport and recreation will serve multiple purposes. First, it would help to educate medical providers and assist them in developing the most effective treatment plans and rehabilitation programs, allowing them to make the best use of available time and resources. Second, it would provide a knowledge base to train programs, trainers, and coaches outside of rehabilitation centers as to what is effective as the majority of these individuals are not medical providers. Third, it would serve to educate third party payers and possibly lead to reimbursement for equipment and services. Fourth, it could lower lifetime health care costs by improving psychosocial well-being while also decreasing functional decline and secondary conditions brought about by inactivity. Finally, and most importantly, it would provide an avenue for veterans with disabilities to return to a fuller, healthier life.

4.2 METHODS

4.2.1 Structure/Content

In preparation for the proposed study investigators at the Human Engineering Research Laboratories developed a data collection tool to investigate the effect of sports participation on the four outcome variables of interest. The Sports Participation Outcomes Research Tool and Comprehensive Uniform Survey (SPORTACUS) was conceptualized by feedback received from various experts in adaptive SER recruited nationally to include: medical providers, coaches, and athletes. The initial tool was fielded in 2009, re-examined based upon findings and necessary changes were made. Test, re-test reliability was analyzed for the current versions of SPORTACUS. The testing was carried out using a subset of 25 individuals with varying disabilities (12 sports participants and 13 non-participants). The tool showed high test/ re-test reliability with an Inter-class correlation coefficient (ICC) of 0.90. The average time needed to complete the initial survey, as examined during the reliability testing, was 16 minutes.

This study consisted of two versions of the SPORTACUS tool given at multiple time points. The first version was administered to the SER participant group. This version of the survey was composed of 5 sections with questions related to demographics (I), medical information (II), assistive technology use (III), community (IV), sports participation (V) and standard measures of self-esteem, depression, posttraumatic growth and QOL. The second version was administered to the group that did not participate in SER. The non-participant version was similar to the participation version and consisted of the same sections. The main difference was that the non-participant version asked questions related to reasons and barriers for non-participation in SER and if they would participate if these conditions were changed.

4.2.2 Demographic Variables

Demographic data collected included age, gender, and ethnic origin. General military information requested included veteran status and rank (current or at time of discharge, if the participant was separated from the service). The demographic section also included information concerning marital and employment status, as well as education level.

4.2.3 Medical Information and Assistive Technology

The second section asked participants to report information regarding their disability and current health status. Data were collected on disability type, level and duration. This section also investigated possible concomitant injuries and/ or disease processes. The third section presented questions related to use of assistive technology devices.

4.2.4 Community Participation

The fourth section asked questions related to the amount of time spent participating in work for pay, education and volunteerism. Follow-up questions determined how important the individual perceived these activities to be and if they were satisfied with how much time they were able to engage in each one or if they wanted more or less.

4.2.5 Sports Participation

The fifth section was related to sports participation before and after the onset of the individuals' disability. The sports participant version asked if the individual participated in SER prior to their disability, if so which activities, at what level and for how long. The non-participant version asked the same questions about participation prior to their disability. Questions were then asked if they had ever participated in SER after the onset of their disability and if so why they stopped. Individuals were then questioned on why they do not participate currently, if those reasons were changed would they still participate and what they would do with their time instead.

4.2.6 Standardized Questionnaires

The final section of the questionnaire presented the Rosenberg Self-Esteem scale (RSES), Center for Epidemiological Studies Depression Scale (CES-D), Posttraumatic Growth Index (PTGI) and the World Health Organization Quality of Life – Brief (WHOQOL BREF).

Self-esteem was measured by the Rosenberg Self-Esteem Scale. The RSES is a reliable and valid measure consisting of ten statements that ask level of agreement (4-point Likert scale). The scale ranges from 0-30. A total score is calculated, with a higher score indicating better self- esteem. Scores between 15 and 25 are within normal range; scores below 15 suggest low self- esteem [33].

Depression was assessed using the Center for Epidemiologic Studies Depression Scale. The CES-D was developed by the National Institute of Mental Health for detecting symptoms of depression. The CES-D, a 10-item continuous score scale ranging from 0 to 30, has been shown to have good reliability and validity. Higher total scores indicate greater levels of depressive symptoms. Traditionally, CES-D scores of 16 or higher indicate significant depressive symptoms [69].

Posttraumatic Growth was assessed with the Posttraumatic Growth Inventory. The PTGI, which assesses posttraumatic growth, measures the degree of change experienced in the aftermath of a traumatic event. PTGI is comprised of five factors: relating to others, new possibilities, personal strength, spiritual change, and appreciation of life, and consists of 21 items. The degree of posttraumatic growth for each item is rated on a 6-point scale (range, 0-105). Reliability and validity of the PTGI have been verified [70].

Quality of life (QOL) was assessed by using portions of the WHOQOL-BREF. The WHOQOL-BREF was developed by the World Health Organization to assess quality of life. The WHOQOL-BREF is a reliable and valid 26 item self-report questionnaire. 24 items constitute four sub–domains: physical health, psychological health, social relationships, and environment, whereas the other two items measure overall QOL and general health [85]. The domain scores denote an individual‘s perception of quality of life in each particular domain. Domain scores are scaled in a positive direction (i.e. higher scores denote higher quality of life). The mean score of items within each domain is used to calculate the domain score. Three domains, physical health, social health and environmental health have been selected to be included in our overall assessment of the subjects.

4.2.7 Participants and Data Collection

This study consisted of two groups: individuals with disabilities that participate in SER and individuals with disabilities that do not participate in SER. The sports group participants were recruited in 2010 and 2011 from registered athletes at the National Veterans Winter Sports Clinic (NVWSC), the United States Olympic Committee Warrior Games (WG), and the National Veterans Wheelchair Games (NVWG). All sports participants were active duty service members or veterans of all branches of the United States Armed Forces who currently have some type of disability. Potential participants approached the designated research area at the events, indicated an interest in participating, were provided an opportunity to read an informational sheet with the essential elements of informed consent and provided verbal consent if they desired to participate.

Sports participants completed surveys at 4 time points. The initial survey was completed before competition began at the event. The second survey was completed directly upon completion of the event. The final two surveys were completed at one month and three months post event. Individuals were excluded if they were unable to complete the questionnaires or if they presented with severe traumatic brain injury (TBI). While severe TBI was an exclusion criterion, no differentiation was made between mild and moderate TBI. No exclusion criteria were based on race, ethnicity, gender, or HIV status. The non-sports participant group was recruited during the same time frame from the Assistive Technology Registry maintained by the Human Engineering Research Laboratories (VA IRB #01185) and the VA Pittsburgh Healthcare System. The non-sport group completed a total of three surveys: initial survey, one month after the initial survey and a final survey three months after completion of the initial. This study was approved through the VA Pittsburgh Healthcare System Institutional Review Board (#02954).

4.2.8 Statistical Analysis

Our descriptive analysis examined demographics and medical history. The analysis of the outcome measures for sport participants versus non-participants was done as a 3 × 2 mixed design ANOVA due to the three measured time points of each outcome and the two levels of the between-subject independent variable, sports participation. Assessments of the assumptions of a mixed design ANOVA were performed for each outcome (post-traumatic growth, self-esteem, depression, physical health domain QOL, social health domain QOL, and environmental health domain QOL). The assumption of normality and compound symmetry were violated for all outcomes and there were a few outliers identified for two of the three outcome measures. Bootstrap p-values were computed instead of performing transformations of the outcome and making other adjustments in order to correct for the violation of assumptions. Correcting for the violations of assumptions could have greatly complicated the interpretation of the results. Bootstrapping does not require the same assumptions and similar results found between the bootstrap p-values and ANOVA p-values. This similarity suggests that the ANOVA results are robust even with the violations of the test assumptions [90]. The analysis of the outcomes for the sport participants was also done as a mixed design ANOVA (4x4x2 for self-esteem, depression and posttraumatic growth and 3x4x2 for QOL domains due to only three time periods) due to the multiple measured time points and multiple between-subject factors. For these analyses, the same steps were taken to check for violations of the assumptions. Bootstrapping was also performed to check the reliability of the results. Secondary correlation analyses were performed to investigate relationships between years lived with disability and the psychosocial outcomes as well as activity intensity and the psychosocial outcomes. All analyses were done using IBM SPSS version 19.0.

4.3 RESULTS

4.3.1 Demographics

A total convenience sample of 163 study participants were recruited (91 sports participants and 72 non-sports participants) from 2010 to 2011. The sports participants group was over the age of 18 and registered athletes at the NVWSC, WG, and the NVWG. The non-sports participant group was recruited through the assistive technology registry and the VA Pittsburgh Healthcare system. The total group included 138 males and 25 females. The average age of the sports participant sample was 48 (+13.4, range 20 to 70) years. The average age of the non-sports participant sample was 56 (+15.2), range 24 to 93).

All individuals from the sports participation group were active duty service members or veterans. The majority (83%) of the non-sports participation group were also service members or veterans. Participants in each group were predominantly Caucasian (69% sports participants, 75% non-sports participants) see table 3.

Table 3. Participant demographics

	Participant (*N = 91*) *freq.* (%)	Control (*N* = 72) *freq.* (%)
Gender		
Male	75 (82.4)	63 (87.5)
Female	16 (17.6)	9 (12.5)
Ethnicity		
African American	11 (12.1)	11 (15.3)
Asian	2 (2.2)	1 (1.4)
Caucasian	63 (69.2)	54 (75.0)
Hispanic/Latino	6 (6.6)	3 (4.2)
American Indian/Alaskan Native	1 (1.1)	2 (2.8)
Pacific Islander	0 (0)	1 (1.4)
Two or more races	8 (8.8)	0 (0)
Education Level		
8th grade or less	0 (0)	1 (1.4)
9th grade through 11th grade	1 (1.1)	1 (1.4)
High school/GED	31 (34.1)	27 (37.5)
Associates	27 (29.7)	14 (19.4)
Bachelors	19 (20.9)	17 (23.6)
Masters	8 (8.8)	5 (6.9)
Doctorate	3 (3.3)	1 (1.4)
Other	2 (2.2)	6 (8.3)
Marital Status		
Single	17 (18.7)	11 (15.3)
Single but living with partner	5 (5.5)	4 (5.6)
Married	45 (49.5)	37 (51.4)
Divorced	19 (20.9)	12 (16.7)
Separated	3 (3.3)	2 (2.8)
Widowed	1 (1.1)	6 (8.3)
Occupational Status		
Working part or fulltime	30 (33)	7 (9.7)
Homemaker	0 (0)	0 (0)
OJT	0 (0)	0 (0)
Not employed by choice	0 (0)	0 (0)
Not employed due to disability	15 (16.5)	34 (47.2)
Retired	39 (42.9)	24 (33.3)
Student	4 (4.4)	2 (2.8)
Unemployed, unable to find a job	2 (2.2)	1 (1.4)
Other	1 (1.1)	4 (5.6)

4.3.2 Medical History

Participant disabilities; spinal cord injury, lower and upper limb amputation, traumatic brain injury, spina bifida, muscular dystrophy, and multiple sclerosis were represented in the two groups (see Table 4). It is important to remember that each participant may have more than one disabling condition.

Table 4. Injury specific demographic information for sport participants vs. non-participants.

	Participant (N = 91) *freq.* (%)	Control (N = 72) *freq.* (%)
Spinal Cord Injury		
No	40 (44)	38 (52.8)
Yes	51 (56)	34 (47.2)
Lower Limb Amputation		
No	76 (83.5)	63 (87.5)
Yes	15 (16.5)	9 (12.5)
Upper Limb Amputation		
No	87 (95.6)	72 (100)
Yes	4 (4.4)	0 (0)
Traumatic Brain Injury		
No	74 (81.3)	57(79.2)
Yes	17 (18.7)	15 (20.8)
Spina Bifida		
No	90 (98.9)	72 (100)
Yes	1 (1.1)	0 (0)
Muscular Dystrophy		
No	90 (98.9)	71 (98.6)
Yes	1 (1.1)	1 (1.4)
Multiple Sclerosis		
No	86 (94.5)	65 (90.3)
Yes	5 (5.5)	7 (9.7)
Cerebral Palsy		
No	91 (100)	72 (100)
Yes	0 (0)	0 (0)

4.3.3 Sports Participant vs. Non-participant Analysis

4.3.3.1 Self-esteem A 3 × 2 mixed design analysis of variance was performed on self-esteem scores as a function of time and sport participation. The within-subject independent variable was time with 3 levels (post event for the sports participant group and initial for the non-sports participant group, 1 month follow-up, and 3 month follow-up). The between-subjects independent variable was sport participation with 2 levels (participant and non-participant). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 64.140, F(6, 162913,737) = 10.470, p < .001, Mauchly's W = .670, = 64.103, p < .001. The assumption of normality was violated in the participant group at all of the time points, Table 5. All other assumptions were met.

The pattern of difference in self-esteem scores among the levels of time were not significantly different between the levels of sport participation, $F(2, 322) = 2.602$, $p = .076$, = .016. There was a significant difference in self-esteem scores among the levels of time averaged across sport participation (Figure 14), $F(2, 322) = 11.594$, $p < .001$, = .067. Sport participants ($M = 24.418$, $SE = .539$) had significantly higher self-esteem scores than non-participants ($M = 19.481$, $SE = .606$) averaged across time (Figure 15), $F(1, 161) = 37.081$, $p < .001$, = .187.

In order to find the pattern of difference in self-esteem scores among the levels of time averaged across sport participation, post hoc marginal comparisons were performed with Bonferroni adjustment. The self-esteem scores were significantly higher immediately post event than at 1 month follow-up or 3 month follow-up averaged across sport participation, $F(1, 161) = 12.515$, $p = .002$, = .072; $F(1, 161) = 14.127$, $p = .001$, = .081, respectively. There were no significant differences in self-esteem scores between 1 month follow-up and 3 month follow-up averaged across sport participation, $F(1, 161) = 1.745$, $p = .565$, = .011. The means and standard errors of self-esteem scores as a function of time averaged across sport participation are reported in Table 6.

Table 5. Test of normality of the self-esteem score as a function of time and sport participation.

Time	Sport Participation	Shapiro-Wilk *W*	*df*	*p*
post event	participant	.852	91	<.00 1
	non-participant	.968	72	.065
1 month follow-up	participant	.896	91	<.001
	non-participant	.978	72	.226
3 month follow-up	participant	.892	91	<.001
	non-participant	.973	72	.126

Table 6. Mean and standard error of self-esteem score as a function of time averaged across sport participation.

Time		*M*	*SE*
post event	63	22.598	.422
1 month follow-up	63	21.734	.423
3 month follow-up	63	21.5 17	.438

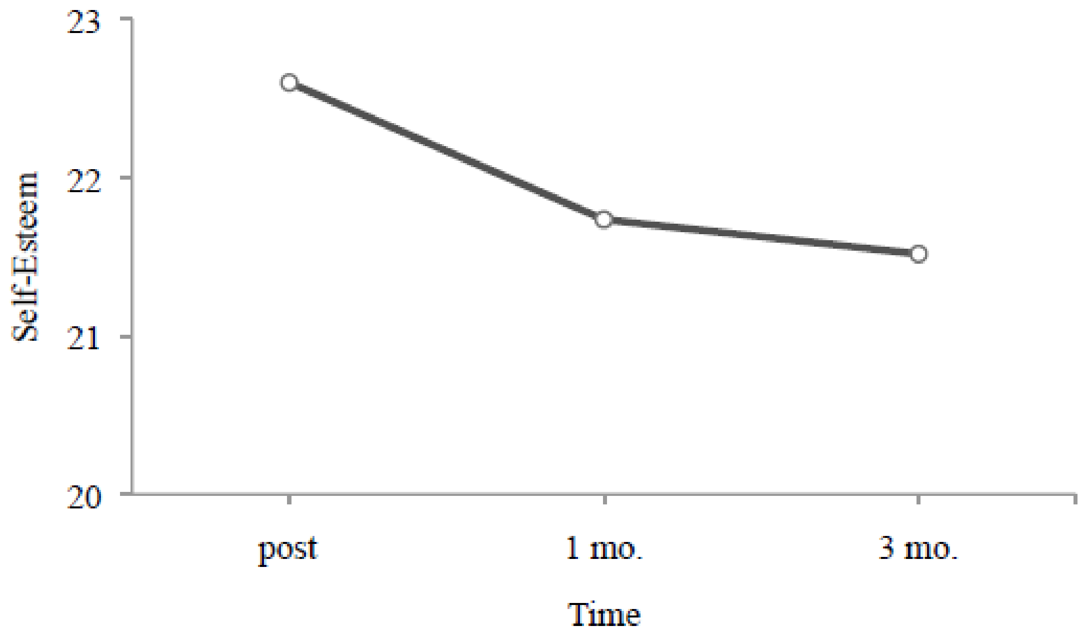


Figure 14. Mean self-esteem scores as a function of time averaged across sport participation.

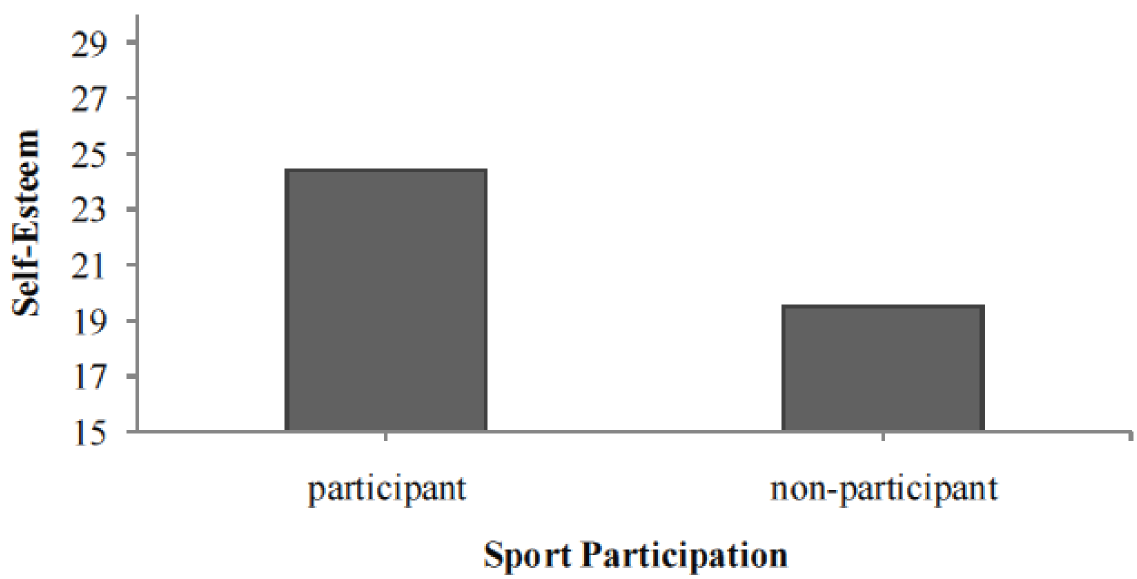


Figure 15. Mean self-esteem scores as a function of sport participation averaged across time.

4.3.3.2 Depression A 3 × 2 mixed design analysis of variance was performed on depression scores as a function of time and sport participation. The within-subject independent variable was time with 3 levels (post event for the sports participant group and initial for the non-sports participant group, 1 month follow-up, and 3 month follow-up). The between-subjects independent variable was sport participation with 2 levels (participant and non-participant). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 84.176, F(6, 162913,737) = 13.740, p < .001, Mauchly's W = .654, = 67.988, p <.001. The assumption of normality was violated in the participant group at all of the time points and the non-participant group at the post time point, Table 7. All other assumptions were met.

The pattern of difference in depression scores among the levels of time were significantly different between the levels of sport participation (Figure 16), $F(2, 322) = 15.186$, $p < .001$, = .086. There was a significant difference in depression scores among the levels of time averaged across sport participation (Figure 17), $F(2, 322) = 11.501$, $p < .001$, = .067. Sport participants ($M = 6.967$, $SE = .535$) had significantly lower depression scores than non-participants ($M = 11.194$, $SE = .602$) averaged across time (Figure 18), $F(1, 161) = 27.538$, $p < .001$, = .146.

In order to find the pattern of difference in depression scores between participants and non-participants at each level of time, simple main effects of sport participation were performed for each time. Sports participants had significantly lower depression scores than non-participants post event, $F(1, 161) = 52.025$, $p < .001$,= .244. Sports participants had significantly lower depression scores than non-participants at 1 month follow-up, $F(1, 161) = 12.131$, $p = .001$,=.070. Sports participants had significantly lower depression scores than non-participants at 3 month follow-up, $F(1, 161) = 14.114$, $p < .001$, = .081.

The means and standard errors of depression scores as a function of time and sport participation are reported in Table 8.

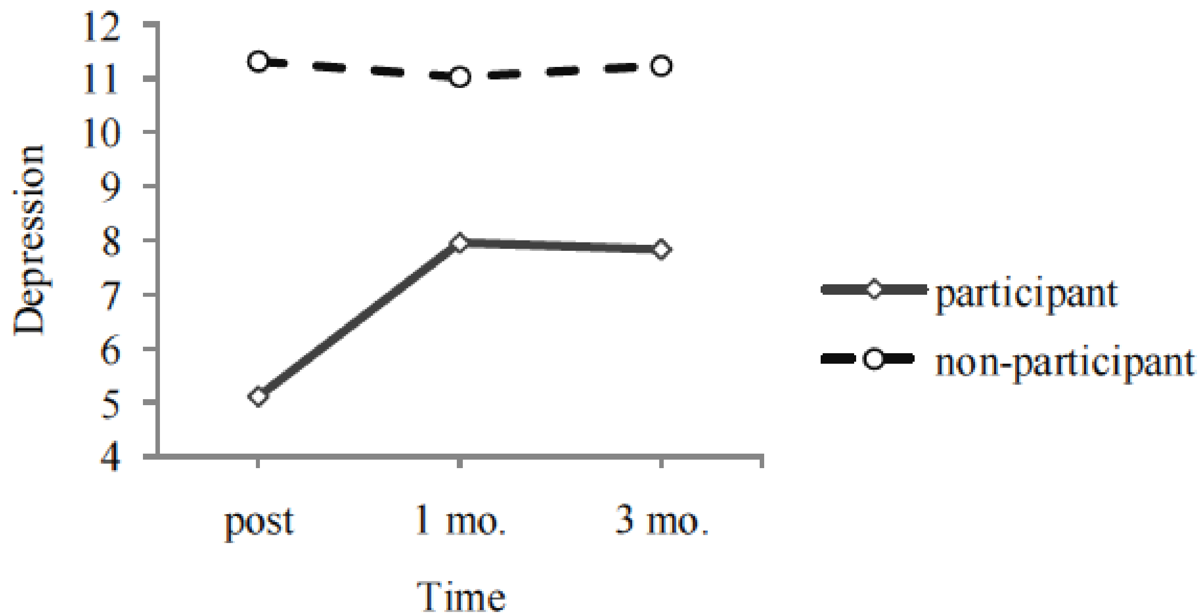


Figure 16. Mean depression scores as a function of time and sport participation.

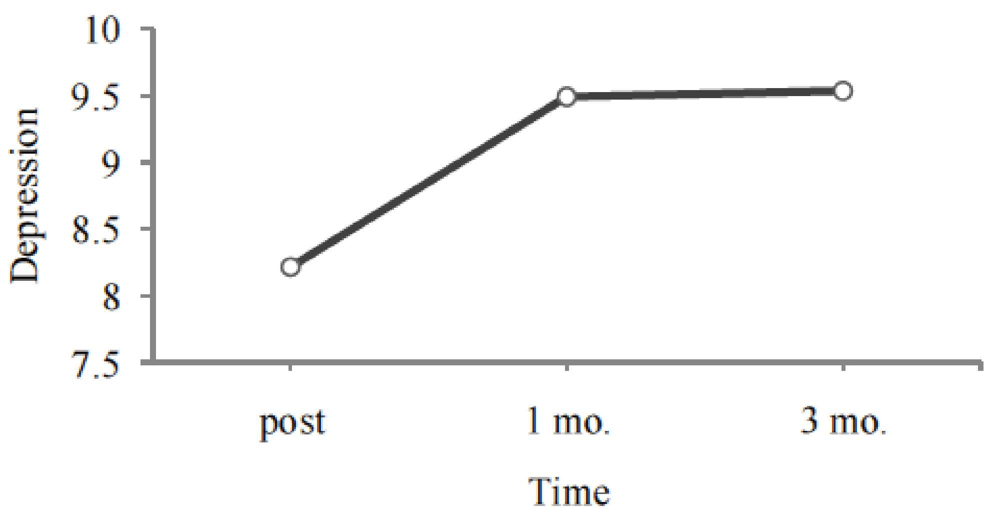


Figure 17. Mean depression scores as a function of time averaged across sport participation.

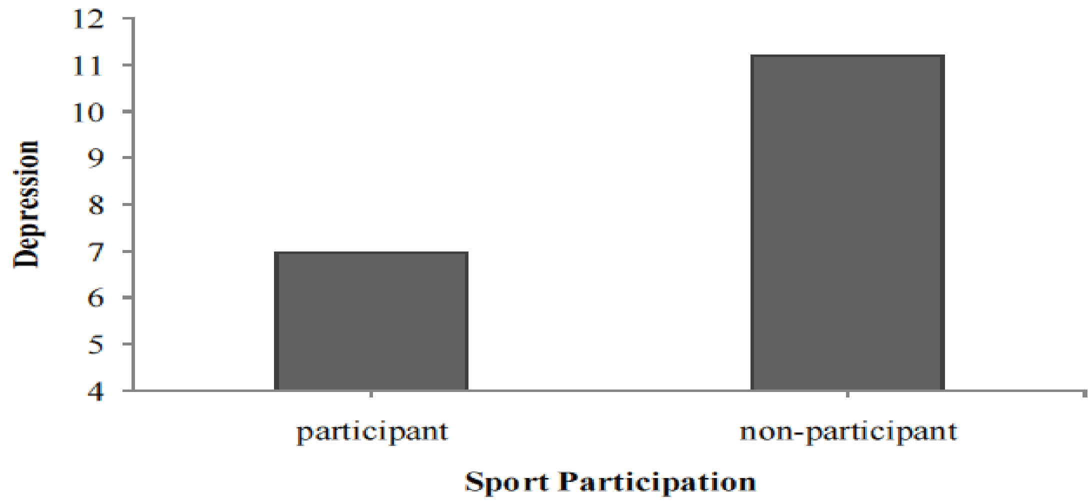


Figure 18. Mean depression scores as a function of sport participation averaged across time.

Table 7. Test of normality of the depression score as a function of time and sport participation.

Time	Sport Participation	Shapiro-Wilk *W*	*p*
post event	participant	.909	<.001
	non-participant	.965	.040
1 month follow-up	participant	.954	.003
	non-participant	.971	.092
3 month follow-up	participant	.952	.002
	non-participant	.977	.201

Table 8. Mean and standard error of depression score as a function of time and sport participation.

Time	Sport Participation	N	*M*	*E*
post event	participant	91	5.110	.572
	non-participant	72	11.900	.643
1 month follow-up	participant	91	7.956	.586
	non-participant	72	11.028	.659
3 month follow-up	participant	91	7.835	.602
	non-participant	72	11.236	.676

4.3.3.3 Posttraumatic Growth A 3 × 2 mixed design analysis of variance was performed on post-traumatic growth scores as a function of time and sport participation. The within- subject independent variable was time with 3 levels (post event for the sports participant group and initial for the non-sports participant group, 1 month follow-up, and 3 month follow-up). The between-subjects independent variable was sport participation with 2 levels (participant and non-participant). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box‘s M = 42.536, F(6, 162913,737) = 6.943, p < .001, Mauchly‘s W = .749, = 46.211, p < .001. The assumption of normality was violated in the participant group at post event and 1 month follow-up, Table 9. All other assumptions were met.

The pattern of difference in post-traumatic growth scores among the levels of time were not significantly different between the levels of sport participation, $F(2, 322) = .937$, $p = .393$, = .006. There was a significant difference in post-traumatic growth scores among the levels of time averaged across sport participation (Figure 19), $F(2, 322) = 10.565$, $p < .001$,= .062.

Sport participants (M = 68.403, SE = 2.080) had significantly higher post-traumatic growth scores than non-participants (M = 49.917, SE = 2.339) averaged across time (Figure 20), $F(1, 161) = 34.876$, $p < .001$,= .178.

In order to find the pattern of difference in post-traumatic growth scores among the levels of time averaged across sport participation, post hoc marginal comparisons were performed with Bonferroni adjustment. The post-traumatic growth scores were significantly higher post event than at 1 month follow-up or 3 month follow-up averaged across sport participation, $F(1, 161) = 10.539$, $p = .004$, = .061; $F(1, 161) = 14.1 60$, $p = .001$, = .081, respectively. There were no significant differences in post-traumatic growth scores between 1 month follow-up and 3 month follow-up averaged across sport participation, $F(1, 161) = 1.259$, $p = .790$, = .008. The means and standard errors of post-traumatic growth scores as a function of time averaged across sport participation are reported in Table 10.

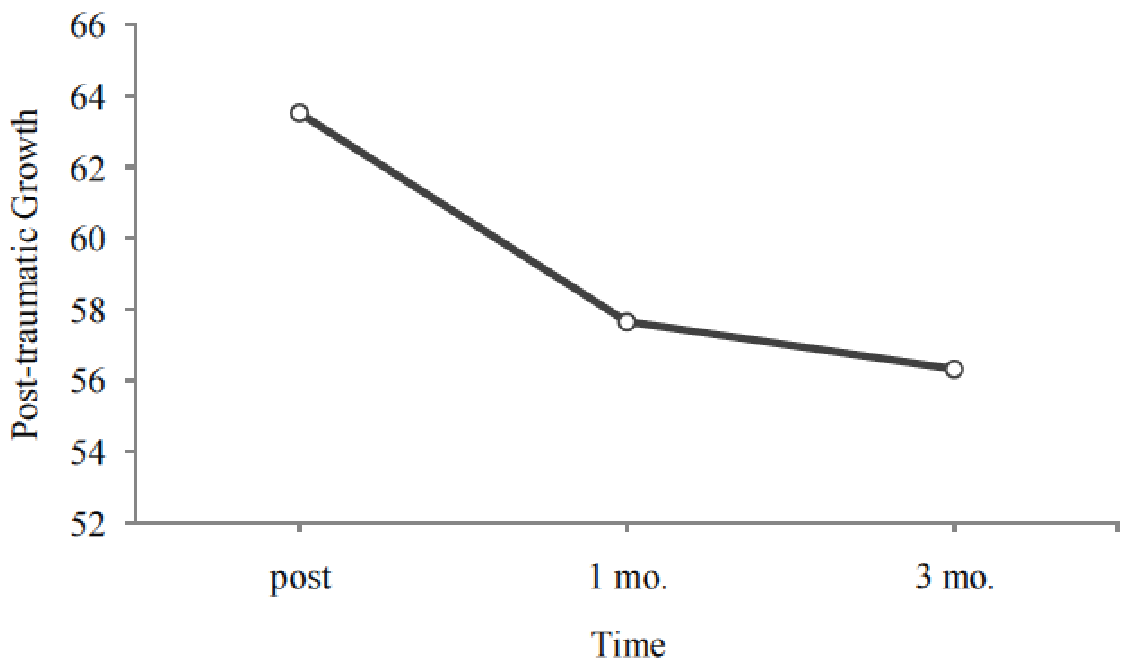


Figure 19. Mean post traumatic growth scores as a function of time averaged across sport participation.

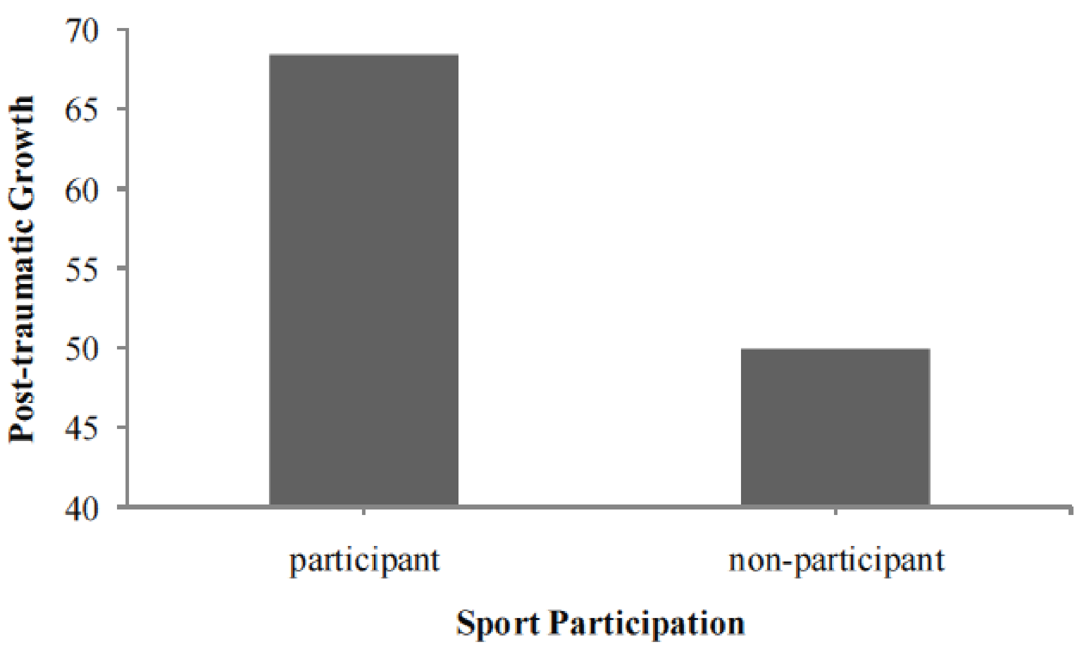


Figure 20. Mean post traumatic growth scores as a function sport participation averaged across time.

Table 9. Test of normality of the post-traumatic growth score as a function of time and sport participation.

Time	Sport Participation	Shapiro-Wilk *W*	*df*	*p*
post event	participant	.959	91	.006
	non-participant	.983	72	.444
1 month follow-up	participant	.972	91	.050
	non-participant	.978	72	.225
3 month follow-up	participant	.975	91	.072
	non-participant	.967	72	.057

Table 10. Mean and standard error of post-traumatic growth score as a function of time averaged across sport participation.

Time	*N*	*M*	*SE*
post event	163	63.521	1.833
1 month follow-up	163	57.645	1.863
3 month follow-up	163	56.313	1.817

4.3.3.4 Quality of life (Physical health domain) A 3 × 2 mixed design analysis of variance was performed on physical health domain QOL scores as a function of time and sport participation. The within-subject independent variable was time with 3 levels (initial, 1 month follow-up, and 3 month follow-up). The between-subjects independent variable was sport participation with 2 levels (participant and non-participant). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box‘s M = 62.651, F(6, 162913.737) = 10.227, p < .001, Mauchly's W = .619, = 76.785, p < .001. The assumption of normality was violated in both the participant and non-participant group at all of the time points, Table 11. All other assumptions were met.

The pattern of difference in physical health domain QOL scores among the levels of time were not significantly different between the levels of sport participation, $F(2, 322) = .536$, $p = .586$, = .003. There were no significant differences in physical health domain QOL scores among the levels of time averaged across sport participation, $F(2, 322) = .569$, $p = .567$, = .004. Sport participants (M = 24.725, SE = .485) had significantly higher physical health domain QOL scores than non-participants (M =21.181, SE = .545) averaged across time (Figure 21), $F(1, 161) = 23.609$, $p < .001$, = .128.

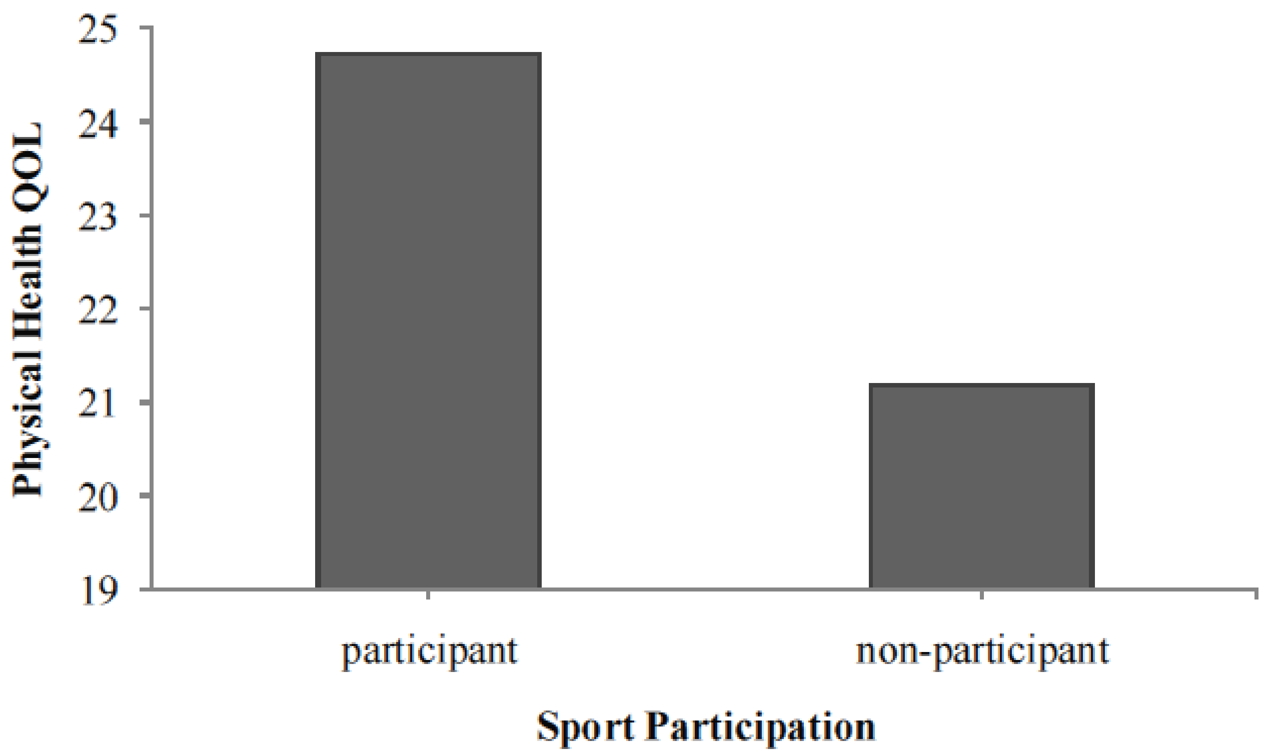


Figure 21. Mean physical health domain QOL scores as a function of sport participation averaged across time.

Table 11. Test of normality of the physical health domain QOL score as a function of time and sport participation.

Time	Sport Participation	Shapiro-Wilk *W*	*df*	*p*
post event	participant	.968	91	.023
	non-participant	.956	72	.013
1 month follow-up	participant	.959	91	.006
	non-participant	.950	72	.006
3 month follow-up	participant	.961	91	.009
	non-participant	.961	72	.024

4.3.3.5 Quality of life (Social health domain) A 3 × 2 mixed design analysis of variance was performed on social health domain QOL scores as a function of time and sport participation. The within-subject independent variable was time with 3 levels (initial, 1 month follow-up, and 3 month follow-up). The between-subjects independent variable was sport participation with 2 levels (participant and non-participant). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 65.179, F(6, 162913.737) = 10.639, p < .001, Mauchly's W = .509, = 107.937, p < .001. The assumption of normality was violated in the participant group at all of the time points and the non-participant group at the initial measurement, Table 12. There was one outlier in the participant group at 1 month follow-up and 3 month follow-up.

The pattern of difference in social health domain QOL scores among the levels of time were not significantly different between the levels of sport participation, $F(2, 322) = .222$,

p =.801,= .001. There was not a significant difference in social health domain QOL scores among the levels of time averaged across sport participation, $F(2, 322) = 2.3\ 12$, $p = .101$,= .014. Sport participants (M = 11.773, SE = .235) had significantly higher social health domain QOL scores than non-participants (M = 9.67 1, SE = .264) averaged across time (Figure 22), $F(1, 161) = 35.420$, $p < .001$, = .180.

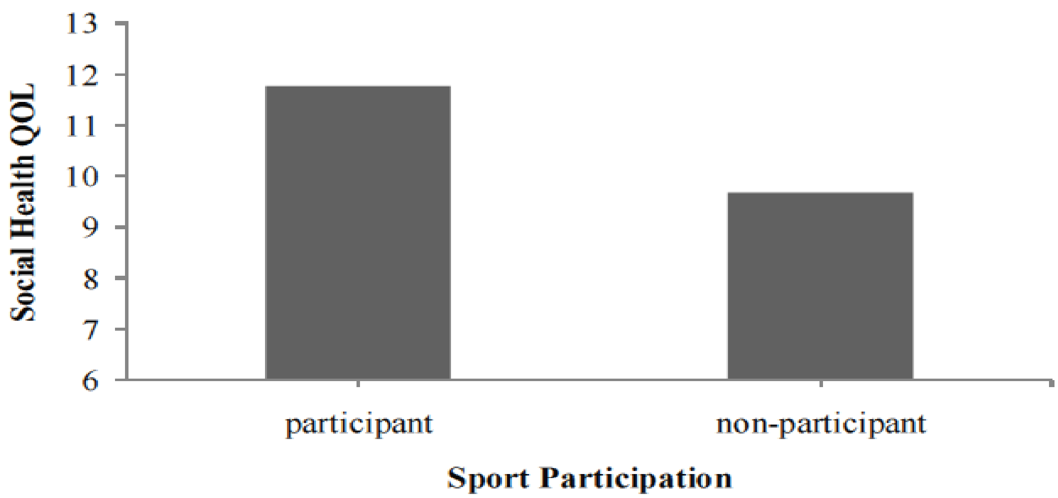


Figure 22. Mean social health domain scores as a function of sport participation averaged across time.

Table 12. Test of normality of the social health domain QOL score as a function of time and sport participation.

Time	Sport Participation	Shapiro-Wilk *W*	*df*	*p*
post event	participant	.931	91	<.001
	non-participant	.965	72	.044
1 month follow-up	participant	.932	91	<.001
	non-participant	.979	72	.264
3 month follow-up	participant	.923	91	<.001
	non-participant	.974	72	.139

4.3.3.6 Quality of life (Environmental health domain) A 3 × 2 mixed design analysis of variance was performed on environmental health domain QOL scores as a function of time and sport participation. The within-subject independent variable was time with 3 levels (initial, 1 month follow-up, and 3 month follow-up). The between-subjects independent variable was sport participation with 2 levels (participant and non-participant). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box‘s M = 76.128, F(6, 162913.737) = 12.427, p < .001, Mauchly‘s W = .499, = 111.216, p < .001. The assumption of normality was violated in the participant group at all of the time points, Table 13. There was one outlier in the participant group at 1 month follow-up and 3 month follow-up.

The pattern of difference in environmental health domain QOL scores among the levels of time were not significantly different between the levels of sport participation, *F*(2, 322) = .710, *p* = .492, = .004. There was a significant difference in environmental health domain QOL scores among the levels of time averaged across sport participation, *F*(2, 322) = 5.765, *p* = .003, = .035 (Figure 23). Sport participants (*M* = 28.886, *SE* = .405) had significantly higher environmental QOL scores than non-participants (*M* = 25.611, *SE* = .456) averaged across time, *F*(1, 161) = 28.860, *p* < .001, = .152 (Figure 24).

In order to find the pattern of difference in environmental health domain QOL scores among the levels of time averaged across sport participation, post hoc marginal comparisons were performed with Bonferroni adjustment. The environmental health domain QOL scores were significantly higher at the initial measurement than at 3 month follow-up averaged across sport participation, *F*(1, 161) = 7.523, *p* = .020, = .045. There was no significant difference in environmental health domain QOL scores between the initial measurement and 1 month follow-up averaged across sport participation, $F(1, 161) = 4.802$, $p = .090$, = .029. There was no significant difference in environmental health domain QOL scores between 1 month follow-up and 3 month follow-up averaged across sport participation, $F(1, 161) = 1.762$, $p = .559$, = .011. The means and standard errors of environmental health domain QOL scores as a function of time averaged across sport participation are reported in Table 14.

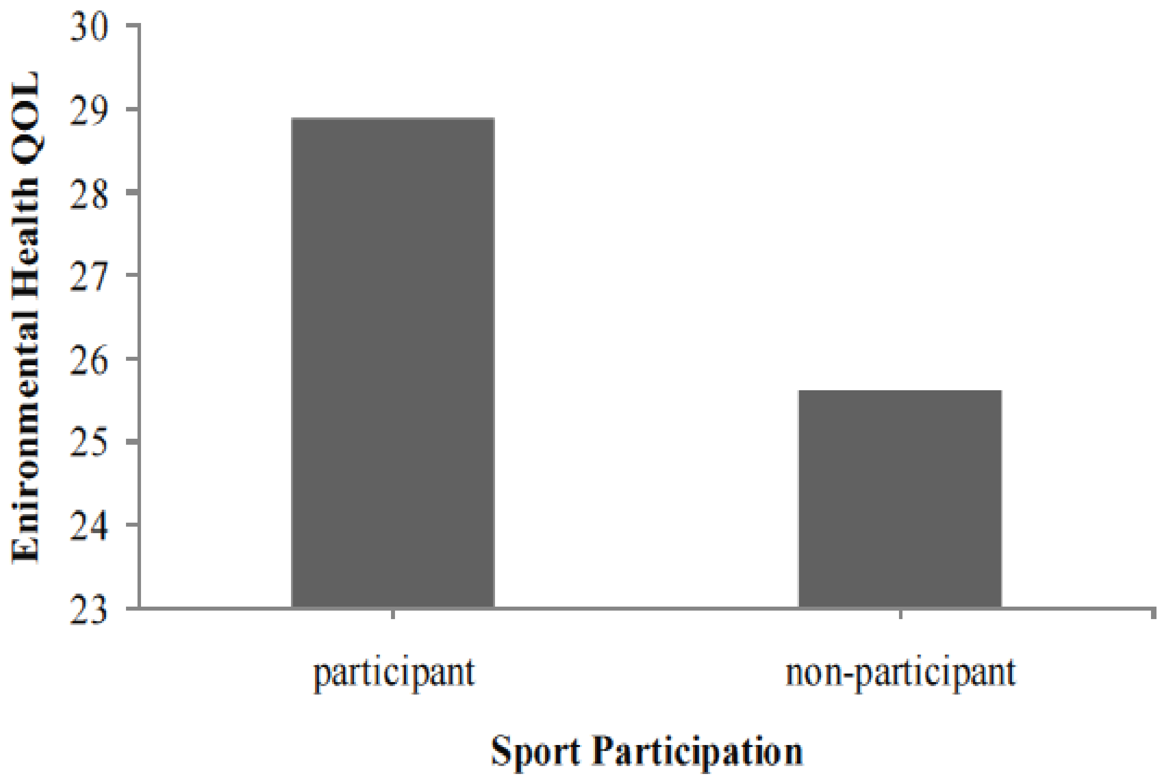


Figure 23. Mean environmental health domain QOL scores as a function of time measured across sports participation

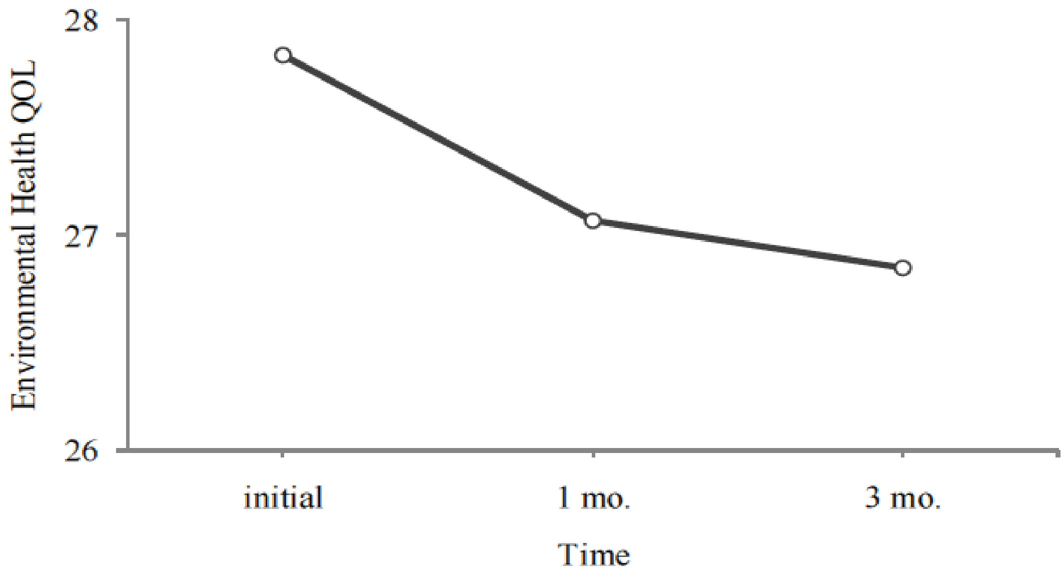


Figure 24. Mean environmental health domain QOL scores as a function of sport participation averaged across time.

Table 13. Test of normality of the environmental health domain QOL score as a function of time and sport participation.

Time	Sport Participation	Shapiro-Wilk *W*	*df*	*p*
post event	participant	.963	91	.011
	non-participant	.983	72	.418
1 month follow-up	participant	.942	91	.001
	non-participant	.989	72	.780
3 month follow-up	participant	.952	91	.002
	non-participant	.968	72	.063

Table 14. Mean and standard error of environmental health domain QOL score as a function of time averaged across sport participation.

Time	*N*	*M*	*SE*
post event	163	27.834	.341
1 month follow-up	163	27.066	.353
3 month follow-up	163	26.847	.361

4.3.4 Sports Participant Analysis

4.3.4.1 Self-esteem A 4 × 4 × 2 mixed design analysis of variance was performed on self-esteem scores as a function of time, years spent participating in sports since onset of disability, and sport activity type. The within-subject independent variable was time with 4 levels (pre event, post event, 1 month follow-up, and 3 month follow-up). The between-subjects independent variables were years participating in sports since onset of disability with 4 levels (less than 1 year, 1 to 5 years, 5 to 10 years, and more than 10 years) and sport activity type with 2 levels (individual activities and a combination of team and individual activities). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 104.643, F(60, 3967.001) = 1.412, p = .021, Mauchly's W = .390, = 75.138, p < .001. There were violations of normality in 8 of the 32 conditions, Table 15. At the post event, 1 month follow up, and 3 month follow up measurements, there was one outlier each in the combined sport activity group who participated in sports more than 10 years since their injury.

The interaction of years participating in sports since onset of disability and activity type on self-esteem scores was not significantly different among the levels of time, $F(9, 243) = .247$, *p* = .987, = .009. The pattern of difference in self-esteem scores among the levels of time were not significantly different among the levels of years participating in sports since onset of disability averaged across activity type, *F*(9, 243) = 1.303, *p* = .236, = .046. The pattern of difference in self-esteem scores among the levels of time were not significantly different between the sport activity types averaged across years participating in sports since onset of disability, *F*(3, 243) = 1.095, *p* = .352, = .013. The pattern of difference in self-esteem scores among the levels of years participating in sports since onset of disability were significantly different between the sport activity types averaged across time (Figure 25), *F*(3, 81) = 6.823, *p* < .001, = .202. There was a significant difference in self-esteem scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, *F*(3, 243) = 9.536, *p* < .001, = .105. There was a significant difference in self-esteem scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, *F*(3, 81) = 7.470, *p* < .001, = .217. Individuals participating in a combination of sports activities (*M* = 25.186, *SE* = .559) had significantly higher self-esteem scores than those only participating in individual events (*M* = 23 .296, *SE* = .659) averaged across time and years participating in sports since onset of disability (Figure 26), *F*(1, 81) = 4.763, *p* = .032, = .056.

In order to find the pattern of difference in self-esteem scores among the levels of years participating in sports since onset of disability at each level of sport activity type averaged across time, simple main effects of years participating in sports since onset of disability were performed for each sport activity type. The significant differences in self-esteem scores among the levels of years participating in sports since onset of disability at each sport activity type averaged across time were followed up by post hoc pairwise comparisons of years participating in sports since onset of disability at each sport activity type with Bonferroni adjustment. There was a significant difference in self-esteem scores among the levels of years participating in sports since onset of disability for those participating in individual sporting events averaged across time, $F(3, 81) = 8.872$, $p < .001$, = .247. There was also a significant difference in self-esteem scores among the levels of years participating in sports since onset of disability for those participating in a combination of sporting events averaged across time, $F(3, 81) = 5.057$, $p = .003$, = .158. For those participating in individual events, the self-esteem scores were significantly lower for those who only participated in sports less than one year as opposed to those who participated in sports 1 to 5 years, 5 to 10 years, or more than 10 years averaged across time, $F(1, 81) = 9.867$, $p = .014$, = .109; $F(1, 81) = 10.214$, $p = .012$, = .112; $F(1, 81) = 19.474$, $p < .001$, = .194, respectively. There were no other significant differences in self-esteem scores among the years participating in sports since onset of disability for those participating in individual events averaged across time, *p*'s > .185. For those participating in a combination of sporting events, the self-esteem scores were significantly lower for those who participated in sports 1 to 5 years as opposed to those who participated in sports less than 1 year, 5 to 10 years, or more than 10 years averaged across time, $F(1, 81) = 8.290$, $p = .031$, = .093; $F(1, 81) = 9.549$, $p = .016$, = .105; $F(1, 81) = 14.627$, $p = .002$, = .153, respectively. There were no other significant differences in self-esteem scores among the years participating in sports since injury for those participating in a combination of sporting events averaged across time, *p*'s = 1. The means and standard errors for years participating in sports since injury by sport activity type averaged across time are reported in Table 16.

In order to find the pattern of difference in self-esteem scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The self-esteem scores were significantly higher post event than pre event, at 1 month, or 3 month follow up averaged across years participating in sports since onset of disability and sport activity type, $F(1, 81) = 21.571$, $p < .001$,= .210; $F(1, 81) = 8.717$, $p = .025$,= .097; $F(1, 81) = 9.023$, $p = .021$,

= .1, respectively. There were no other significant differences in self-esteem scores among the remaining levels of time averaged across years participating in sports since injury and sport activity type, p's > .198.

The means and standard errors for time averaged across years participating in sports since injury and sport activity type are reported in Table 17.

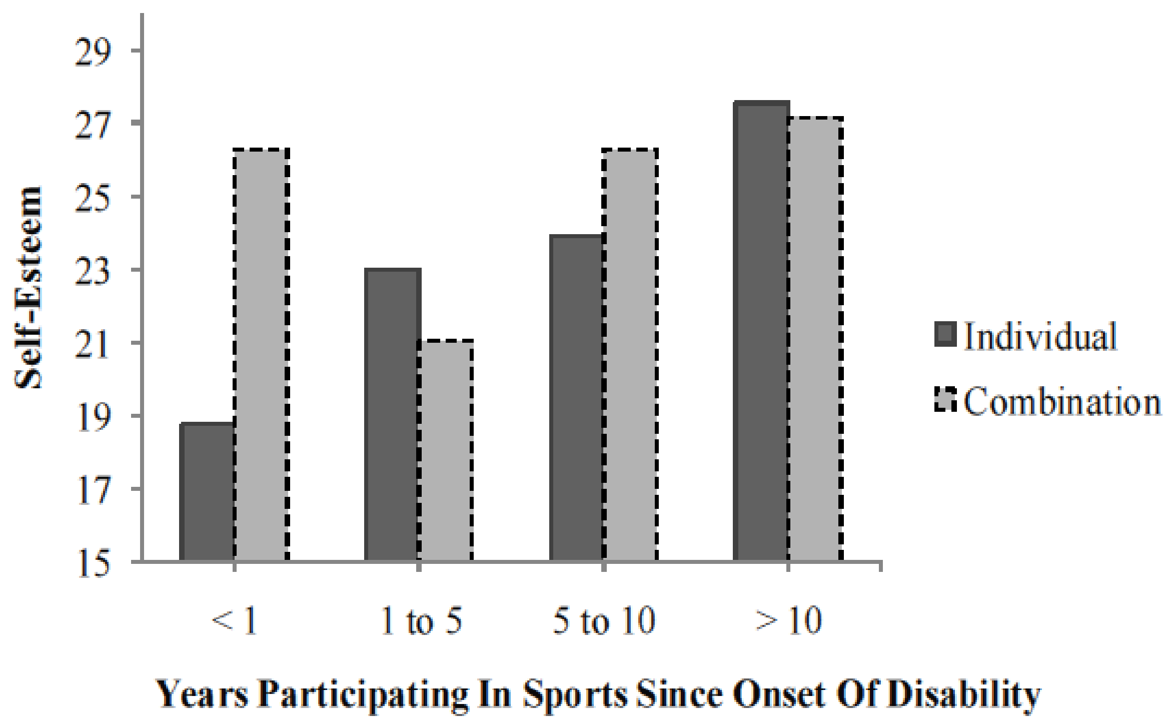


Figure 25. Mean Self-esteem scores as a function of years participating in sport since onset of disability and sport activity type.

Table 15. Test of normality of the self-esteem score as a function of time, years participating in sports since onset of disability, and sport activity type.

Time	Years Participating	Activity Type	Shapiro-Wilk *W*	*df*	*p*
pre event	less than 1	individual	.914	18	.101
		combination	.911	9	.322
	1 to 5	individual	.855	12	.042
		combination	.825	7	.071
	5 to 10	individual	.926	7	.518
		combination	.917	13	.229
	greater than 10	individual	.991	4	.962
		combination	.765	19	<.001
post event	less than 1	individual	.955	18	.517
		combination	.848	9	.072
	1 to 5	individual	.927	12	.353
		combination	.895	7	.302
	5 to 10	individual	.778	7	.025
		combination	.914	13	.210
	greater than 10	individual	.863	4	.272
		combination	.709	19	<.001
1 month follow-up	less than 1	individual	.896	18	.048
		combination	.843	9	.062
	1 to 5	individual	.964	12	.845
		combination	.843	7	.107
	5 to 10	individual	.853	7	.132
		combination	.900	13	.135
	greater than 10	individual	.827	4	.161

Table 16. Mean and standard error of self-esteem score as a function of years participating in sports since onset of disability and sport activity type averaged across time.

Years Participating	Activity Type	*N*	*M*	*SE*
less than 1	Individual	18	18.750	.852
	Combination	9	26.278	1.204
1 to 5	Individual	12	22.979	1.043
	Combination	7	21.036	1.365
5 to 10	Individual	7	23.893	1.365
	Combination	13	26.269	1.002
greater than 10	Individual	4	27.562	1.806
	Combination	19	27.145	.829

Table 17. Mean and standard error of self-esteem score as a function of time averaged across years participating in sports since onset of disability and sport activity type.

Time	*N*	*M*	*SE*
pre event	89	23.124	.553
post event	89	25.575	.445
1 month follow-up	89	24.212	.511
3 month follow-up	89	24.045	.551

In order to find the pattern of difference in self-esteem scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The self-esteem scores were significantly higher for those who have participated in sports for more than 10 years than for those who participated in sports for one year or less or 1 to 5 years averaged across time and activity type, $F(1, 81) = 15.297$, $p = .001$, 2 = .159; $F(1, 81) = 16.565$, $p = .001$, 2 = .170, respectively (Figure 26). There were no other significant differences in self-esteem scores among the remaining levels of years participating in sports since injury averaged across time and activity type, p's > .149. The means and standard errors of self-esteem scores for years participating in sports since injury averaged across time and sport activity type are reported in Table 18.

Table 18. Mean and standard error of self-esteem score as a function of years participating in sports since onset of disability averaged across time and sport activity type.

Years Participating	*N*	*M*	*SE*
less than 1	27	22.514	.737
1 to 5	19	22.007	.859
5 to 10	20	25.081	.847
greater than 10	23	27.354	.994

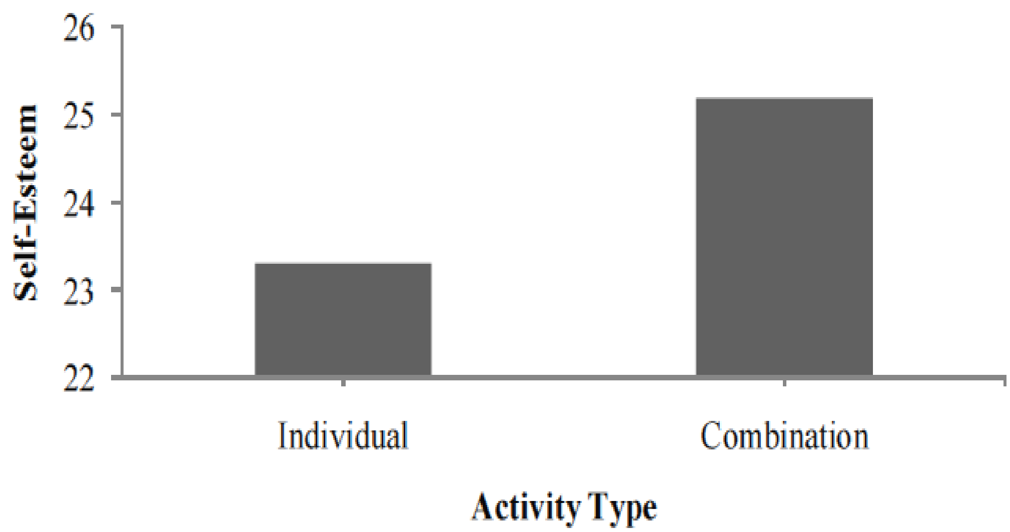


Figure 26. Mean self-esteem scores as a function of activity type.

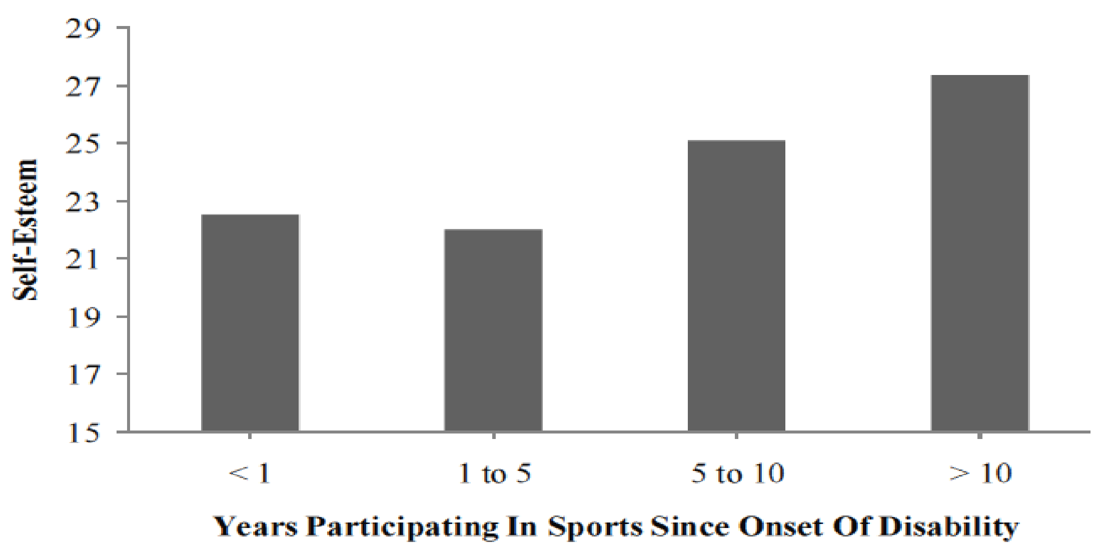


Figure 27. Mean self-esteem scores as a function of years participating in sports since onset of disability.

4.3.4.2 Depression A 4 × 4 × 2 mixed design analysis of variance was performed on depression scores as a function of time, years participating in sports since onset of disability, and sport activity type. The within-subject independent variable was time with 4 levels (pre event, post event, 1 month follow-up, and 3 month follow-up). The between-subjects independent variables were years participating in sports since injury with 4 levels (less than 1 year, 1 to 5 years, 5 to 10 years, and more than 10 years) and sport activity type with 2 levels (individual activities and a combination of team and individual activities). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 85.386, F(60,3967.001) = 1.152, p = .199, Mauchly's W = .318, 52 = 91.381, p < .001. There were violations of normality in 8 of the 32 conditions, Table 19. All other assumptions were met.

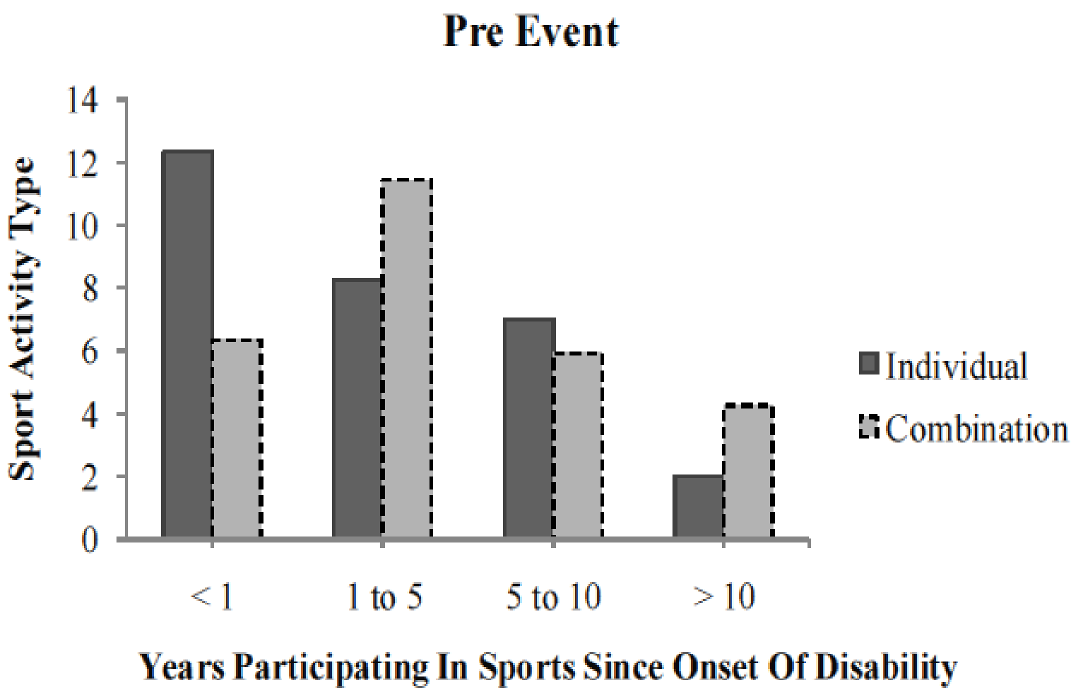
The interaction of years participating in sports since onset of disability and activity type on depression scores was significantly different among the levels of time (Figure 28), *F*(9, 243) = 2.295, *p* = .017, *2* = .078. The pattern of difference in depression scores among the levels of time were not significantly different among the levels of years participating in sports since onset of disability averaged across activity type, *F*(9, 243) = 1.233, *p* = .275, *2* = .044. The pattern of difference in depression scores among the levels of time were not significantly different between the sport activity types averaged across years participating in sports since onset of disability, *F*(3, 243) = 2.272, *p* = .081, *2* = .027. The pattern of difference in depression scores among the levels of years participating in sports since onset of disability were not significantly different between the sport activity types averaged across time, *F*(3, 81) = 2.449, *p* = .070, *2* = .083. There was a significant difference in depression scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, *F*(3, 243) = 7.943, *p* < .001, *2* = .089. There was a significant difference in depression scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, *F*(3, 81) = 5.070, *p* = .003, *2* = .158. There was not a significant difference in depression scores between the sport activity types averaged across time and years participating in sports since onset of disability, *F*(1, 81) = 2.278, *p* = .135, *2* = .027.

In order to find the difference in interaction of years participating in sports since onset of disability and activity type on depression scores among the levels of time, simple two-way interactions of years participating in sports since injury and sport activity type were performed at each level of time.

The significant differences in the interaction of years participating in sports since onset of disability and sport activity type on depression scores among the levels of time were followed up by simple main effects of years participating in sports since onset of disability at each sport activity type for specific levels of time. The significant differences in depression scores among the levels of years participating in sports since onset of disability at each sport activity type at specific levels of time were followed up by post hoc pairwise comparisons of years participating in sports since onset of disability for those participating in individual events using the Bonferroni adjustment.

The pattern of differences in depression scores among the levels of years participating in sports since onset of disability were not significantly different between the sport activity types pre event, *F*(1, 81) = 2.652, *p* = .054, *2* = .089. The pattern of differences in depression scores among the levels of years participating in sports onset of disability were not significantly different between the sport activity types post event, *F*(1, 81) = .890, *p* = .450, *2* = .032. The pattern of differences in depression scores among the levels of years participating in sports since onset of disability were significantly different between the sport activity types at 1 month follow-up, *F*(1, 81) = 3.244, *p* = .026, *2* = .107. The pattern of differences in depression scores among the levels of years participating in sports since onset of disability were not significantly different between the sport activity types at 3 month follow up, *F*(1, 81) =

2.310, p = .082, *2* = .079. There was a significant difference in depression scores among the levels of years participating in sports since onset of disability for those participating in individual sporting events at 1 month follow-up, F(3, 81) = 4.157, p = .009, *2* = .133. There was not a significant difference in depression scores among the levels of years participating in sports since onset of disability for those participating in a combination of sporting events at 1 month follow- up, F(3, 81) = 2.246, p = .089, *2* = .077. For those participating in individual events, the depression scores were significantly higher for those who only participated in sports less than one year as opposed to those who participated in sports 5 to 10 years at 1 month follow-up, F(1,81) = 9.545, p = .016, *2* = .105. There were no other significant differences in depression scores among the levels of years participating in sports since onset of disability for those who participated in individual events at 1 month follow-up, p’s > .108. The means and standard errors for time by years participating in sports since injury by sport activity type are reported in Table 20.


Pre Event
Sport Activity Type
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12
10
8
6
4
2
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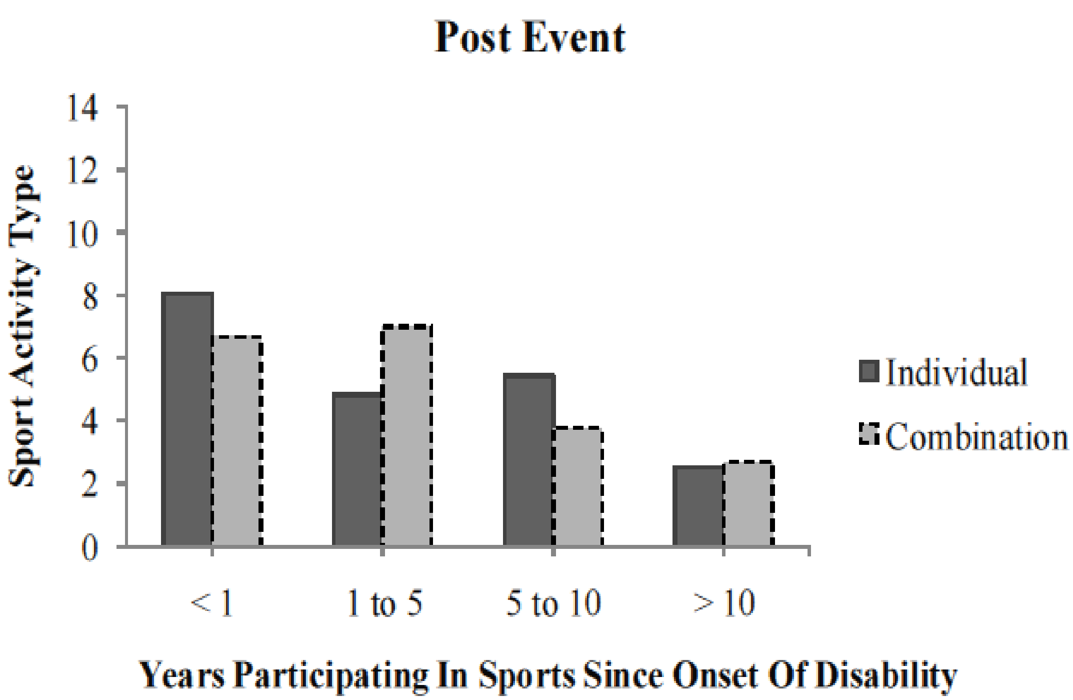
5 to 10
> 10
Years Participating In Sports Since Onset Of Disability
Individual
Combination


Post Event
Sport Activity Type
14
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Years Participating In Sports Since Onset Of Disability
Individual
Combination

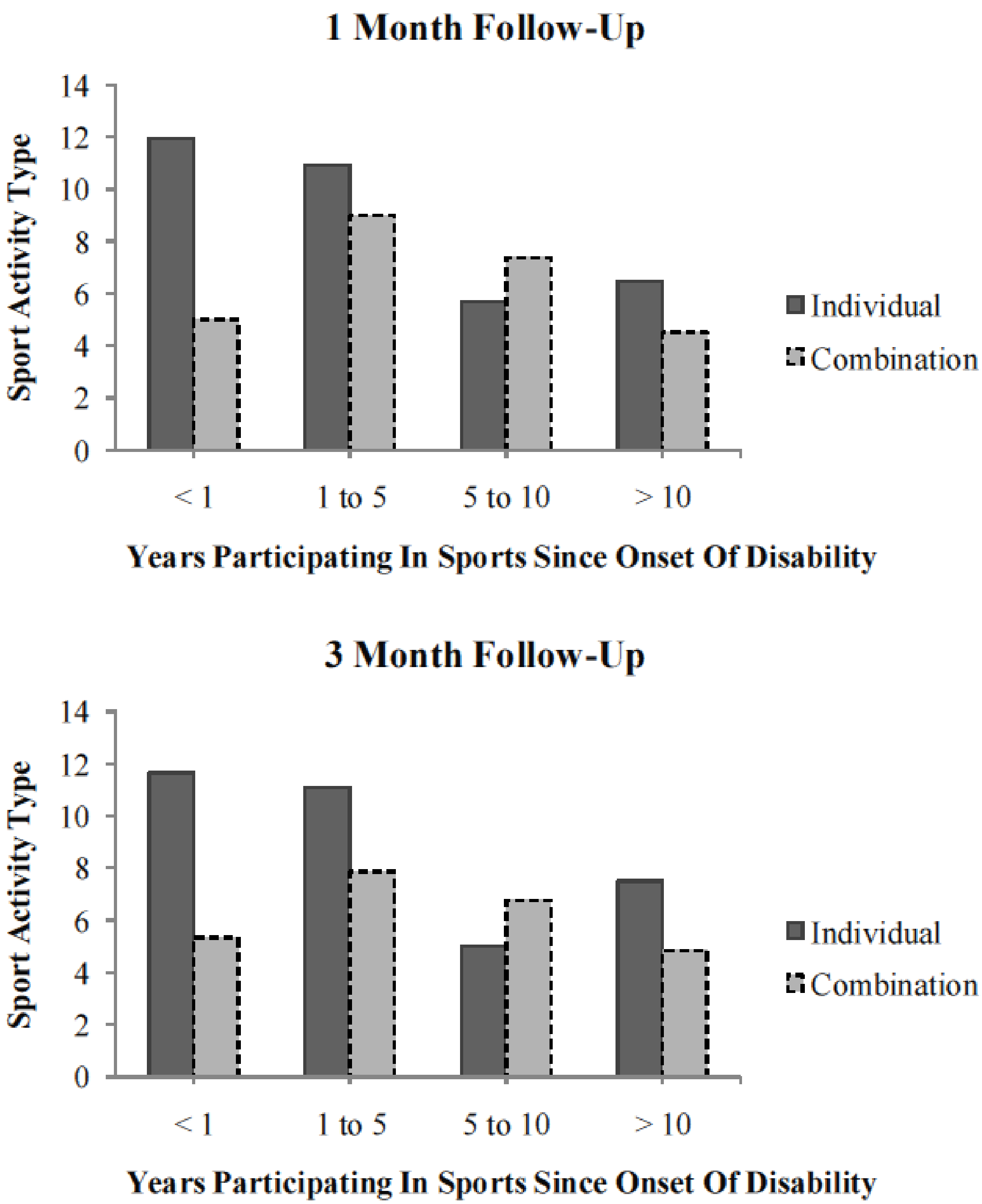

Figure 28. Mean depression scores as a function of time, years participating in sports since onset of disability and sport activity type.

Table 19. Test of normality of the depression score as a function of time, years participating in sports since onset of disability, and sport activity type.

Time	Years Participating	Activity Type	Shapiro-Wilk *W*	*df*	*p*
pre event	less than 1	individual	.977	18	.920
		combination	.811	9	.027
	1 to 5	individual	.840	12	.028
		combination	.945	7	.681
	5 to 10	individual	.822	7	.068
		combination	.845	13	.025
	greater than 10	individual	.773	4	.062
		combination	.887	19	.029
post event	less than 1	individual	.957	18	.543
		combination	.874	9	.136
	1 to 5	individual	.912	12	.226
		combination	.970	7	.899
	5 to 10	individual	.920	7	.466
		combination	.847	13	.026
	greater than 10	individual	.849	4	.224
		combination	.851	19	.007
1 month follow-up	less than 1	individual	.940	18	.284
		combination	.863	9	.103
	1 to 5	individual	.862	12	.052
		combination	.825	7	.071
	5 to 10	individual	.863	7	.161
		combination	.864	13	.043
	greater than 10	individual	.801	4	.103
		combination	.934	19	.207
3 month follow-up	less than 1	individual	.963	18	.653
		combination	.844	9	.064
	1 to 5	individual	.881	12	.090
		combination	.902	7	.345
	5 to 10	individual	.751	7	.013
		combination	.874	13	.060
	greater than 10	individual	.935	4	.625
		combination	.938	19	.241

Table 20. Mean and standard error of depression score as a function of time, years participating in sports since onset of disability and sport activity type.

Time	Years Participating	Activity Type	*N*	*M*	*SE*
pre event	less than 1	Individual	18	12.333	1.353
		Combination	9	6.333	1.914
	1 to 5	Individual	12	8.250	1.658
		Combination	7	11.429	2.170
	5 to 10	Individual	7	7.000	2.170
		Combination	13	5.923	1.593
	greater than 10	Individual	4	2.000	2.871
		Combination	19	4.263	1.317
post event	less than 1	Individual	18	8.056	.948
		Combination	9	6.667	1.340
	1 to 5	Individual	12	4.833	1.161
		Combination	7	7.000	1.520
	5 to 10	Individual	7	5.429	1.520
		Combination	13	3.769	1.115
	greater than 10	Individual	4	2.500	2.011
		Combination	19	2.684	.923
1 month follow-up	less than 1	Individual	18	11.944	1.067
		Combination	9	5.000	1.509
	1 to 5	Individual	12	10.917	1.307
		Combination	7	9.000	1.711
	5 to 10	Individual	7	5.714	1.711
		Combination	13	7.385	1.256
	greater than 10	Individual	4	6.500	2.264
		Combination	19	4.526	1.039
3 month follow-up	less than 1	Individual	18	11.667	1.169
		Combination	9	5.333	1.654
	1 to 5	Individual	12	11.083	1.432
		Combination	7	7.857	1.875
	5 to 10	Individual	7	5.000	1.875
		Combination	13	6.769	1.376
	greater than 10	Individual	4	7.500	2.481
		Combination	19	4.842	1.138

In order to find the pattern of difference in depression scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The depression scores were significantly lower for those who have participated in sports for more than 10 years than for those who participated in sports for one year or less or 1 to 5 years averaged across time and activity type, $F(1, 81) = 9.756$, $p = .015$, *2* = .108; $F(1, 81) = 10.350$, $p = .011$ *2* = .113, respectively (Figure 29). There were no other significant differences in depression scores among the remaining levels of years participating in sports since injury averaged across time and sport activity type, *p*'s > .143. The means and standard errors of depression scores for years participating in sports since injury averaged across time and sport activity type are reported in Table 21.

Table 21. Mean and standard error of depression score as a function of years participating in sports since onset of disability averaged across time and sport activity type.

Years Participating	*N*	*M*	*SE*
less than 1	27	8.417	.776
1 to 5	19	8.796	.903
5 to 10	20	5.874	.891
greater than 10	23	4.352	1.045

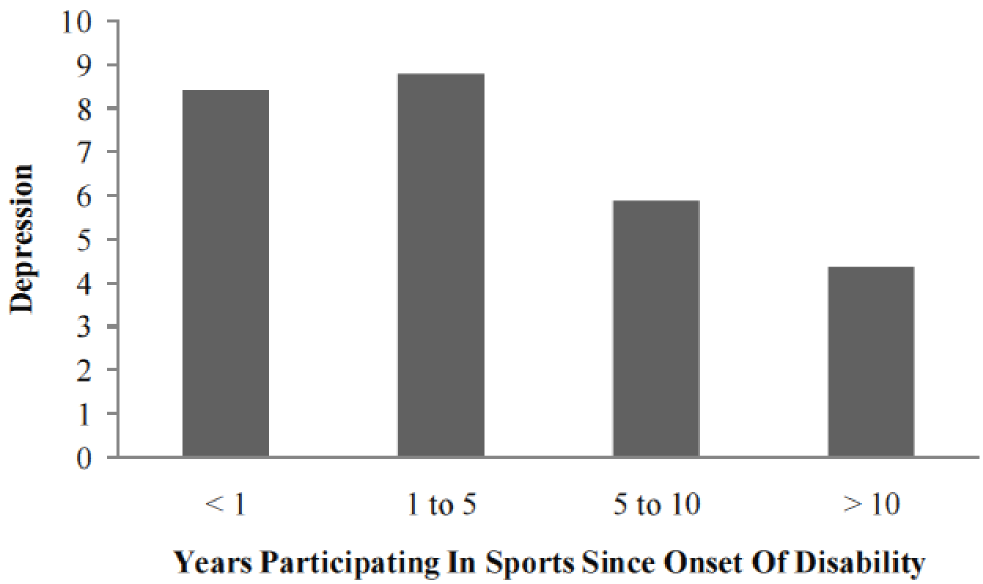

Figure 29. Mean depression scores as a function of years participating in sports since onset of disability.

In order to find the pattern of difference in depression scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The depression scores were significantly lower post event than at pre-event, 1 month, or 3 month follow-ups, averaged across years participating since onset of disability and activity type (Figure 30), $F(1, 81) = 13.758$, $p = .002$, $2 = .145$; $F(1, 81) = 18.627$, $p < .001$, $2 = .187$; $F(1, 81) = 15.269$, $p < .001$, $2 = .159$, respectively. There were no other significant differences. The means and standard errors of depression scores for time averaged across years participating in sports since onset of disability and sport activity type are reported in Table 22.

Table 22. Mean and standard error of depression score as a function of time averaged across years participating in sports since injury and sport activity type.

Time	*N*	*M*	*SE*
pre event	89	7.191	.687
post event	89	5.117	.481
1 month follow-up	89	7.623	.541
3 month follow-up	89	7.506	.593

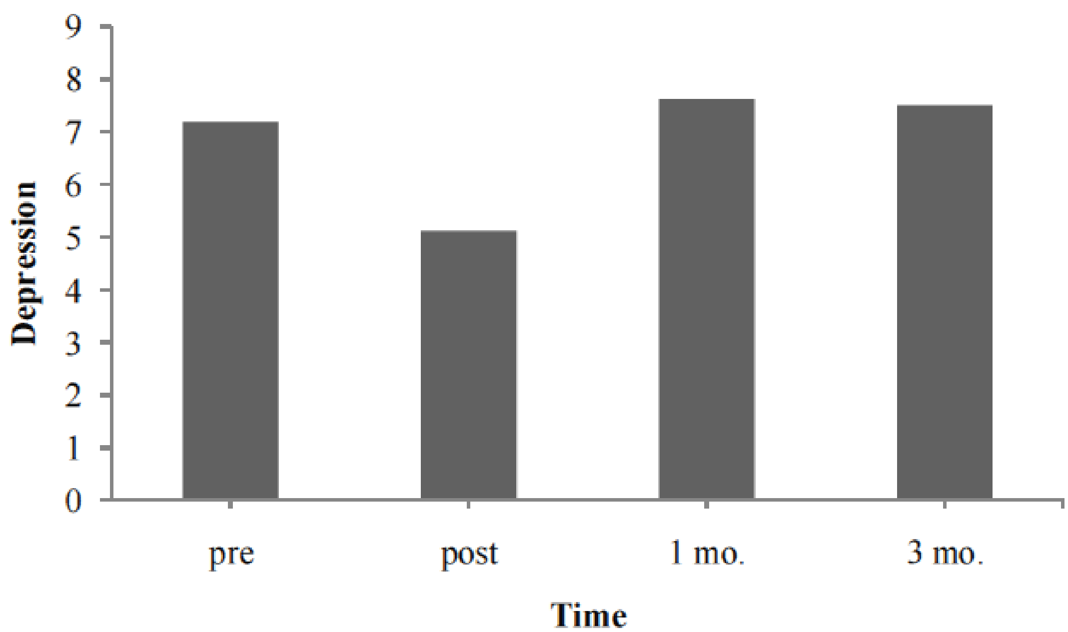

Figure 30. Mean depression scores as a function of time.

4.3.3.3 Posttraumatic Growth A 4 × 4 × 2 mixed design analysis of variance was performed on posttraumatic growth scores as a function of time, years participating in sports since onset of disability, and sport activity type. The within-subject independent variable was time with 4 levels (pre event, post event, 1 month follow-up, and 3 month follow-up). The between-subjects independent variables were years participating in sports since onset of disability with 4 levels (less than 1 year, 1 to 5 years, 5 to 10 years, and more than 10 years) and sport activity type with 2 levels (individual activities and a combination of team and individual activities). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 126.647, F(60,3967.001) = 1.709, p = .001, Mauchly's W = .356, 52 = 82.294, p < .001. There were violations of normality in 5 of the 32 conditions, Table 23.

The interaction of years participating in sports since onset of disability and activity type on posttraumatic growth scores was not significantly different among the levels of time, *F*(9, 243) = 1.969, *boot p* = .081, *2* = .068. The pattern of difference in posttraumatic growth scores among the levels of time were not significantly different among the levels of years participating in sports since onset of disability averaged across activity type, *F*(9, 243) = 1.037, *p* = .411, *2* = .037. The pattern of difference in posttraumatic growth scores among the levels of time were not significantly different between the sport activity types averaged across years participating in sports since onset of disability, *F*(3, 243) = .312, *p* = .817, *2* = .004. The pattern of difference in posttraumatic growth scores among the levels of years participating in sports since onset of disability were not significantly different between the sport activity types averaged across time, *F*(3, 81) = 1.247, *p* = .298, *2* = .044. There was a significant difference in posttraumatic growth scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, *F*(3, 243) = 9.496, *p* < .001, *2* = .105. There was a significant difference in post-traumatic growth scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, *F*(3, 81) = 5.782, *p* = .001, *2* = .176. There was not a significant difference in posttraumatic growth scores between the sport activity types averaged across time and years participating in sports since onset of disability, *F*(1, 81) = .030, *p* = .864, *2* < .001.

In order to find the pattern of difference in posttraumatic growth scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The posttraumatic growth scores were significantly higher pre event than at 1 month or 3 month follow up averaged across years participating in sports since onset of disability and sport activity type, $F(1, 81) = 12.568$, $p = .004$, 2 = .134; $F(1, 81) = 13.512$, $p = .003$, 2 = .143, respectively. The posttraumatic growth scores were also significantly higher post event than at 1 month or 3 month follow up averaged across years participating in sports since onset of disability and sport activity type, $F(1, 81) = 9.580$, $p = .016$, 2 = .106; $F(1, 81) = 9.779$, $p = .015$, 2 = .108, respectively. The posttraumatic growth scores were not significantly different between pre and post event or between 1 month and 3 month follow up averaged across years participating in sports since onset of disability and sport activity type, $F(1, 81) = .599$, $p = 1$, 2 = .007; $F(1, 81) = .109$, $p = 1$, 2 = .001, respectively. The means and standard errors for time averaged across years participating in sports since injury and sport activity type are reported in Table 24.

In order to find the pattern of difference in posttraumatic growth scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The posttraumatic growth scores were significantly higher for those who have spent 5 to 10 years or 10 years or more participated in sports since onset of disability than for those who only participated in sports for a year or less since onset of disability averaged across time and sport activity type (Figure 31), $F(1, 81) = 11.857$, $p = .005$, 2 = .128; $F(1, 81) = 12.209$, $p = .005$, 2 = .131, respectively (Figure 18). There were no other significant differences in posttraumatic growth scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, *p's* > .414. The means and standard errors for years participating in sports since injury averaged across time and sport activity type are reported in Table 25.

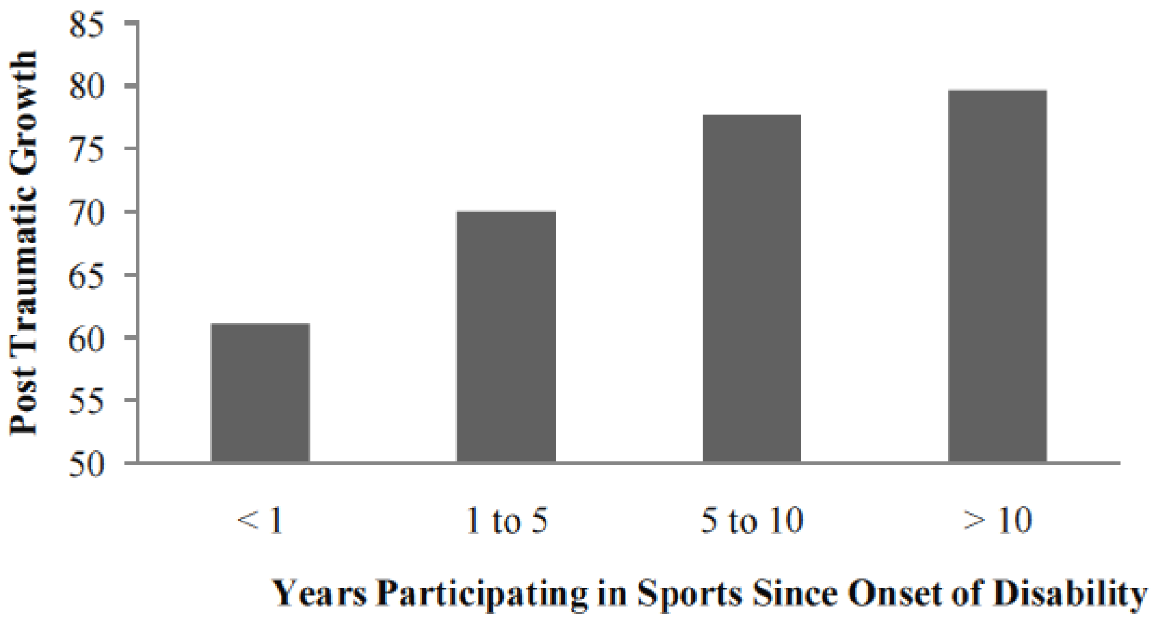

Figure 31. Mean posttraumatic growth scores as a function of years participating in sports since onset of disability.

Table 23. Test of normality of the post-traumatic growth score as a function of time, years participating in sports since onset of disability, and sport activity type.

Time	Years Participating	Activity Type	Shapiro-Wilk *W*	*df*	*p*
pre event	less than 1	individual	.978	18	.929
		combination	.934	9	.524
	1 to 5	individual	.968	12	.888
		combination	.787	7	.030
	5 to 10	individual	.903	7	.347
		combination	.917	13	.231
	greater than 10	individual	.962	4	.792
		combination	.887	19	.029
post event	less than 1	individual	.883	18	.029
		combination	.894	9	.217
	1 to 5	individual	.969	12	.900
		combination	.891	7	.281
	5 to 10	individual	.950	7	.732
		combination	.909	13	.178
	greater than 10	individual	.962	4	.792
		combination	.948	19	.372
1 month follow-up	less than 1	individual	.972	18	.837
		combination	.932	9	.504
	1 to 5	individual	.826	12	.019
		combination	.902	7	.342
	5 to 10	individual	.925	7	.509
		combination	.941	13	.466
	greater than 10	individual	.801	4	.103
		combination	.965	19	.667
3 month follow-up	less than 1	individual	.966	18	.725
		combination	.956	9	.760
	1 to 5	individual	.841	12	.028
		combination	.893	7	.292
	5 to 10	individual	.854	7	.134
		combination	.963	13	.793
	greater than 10	individual	.863	4	.272
		combination	.957	19	.508

Table 24. Mean and standard error of post-traumatic growth score as a function of time averaged across years participating in sports since onset of disability and sport activity type.

Time	*N*	*M*	*SE*
pre event	89	78.332	2.459
post event	89	76.344	2.462
1 month follow-up	89	67.083	2.669
3 month follow-up	89	66.646	2.511

Table 25. Mean and standard error of post-traumatic growth score as a function of years participating in sports since onset of disability averaged across time and sport activity type.

Years Participating	*N*	*M*	*SE*
less than 1	27	61.069	3.166
1 to 5	19	70.028	3.689
5 to 10	20	77.672	3.636
greater than 10	23	79.635	4.267

4.3.3.4 Quality of life (Physical health domain) A 3 × 4 × 2 mixed design analysis of variance was performed on the physical domain QOL scores as a function of time, years participating in sports since onset of disability, and sport activity type. The within-subject independent variable was time with 3 levels (pre event, 1 month follow-up, and 3 month follow-up). The between-subjects independent variables were years participating in sports since onset of disability with 4 levels (less than 1 year, 1 to 5 years, 5 to 10 years, and more than 10 years) and sport activity type with 2 levels (individual activities and a combination of team and individual activities). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 98.705, $F(42, 2072.544) = 1.914$, $p < .001$, Mauchly's W = .423, 22 = 68.796, $p < .001$. There were violations of normality in 2 of the 24 conditions, Table 26. At the pre event measurement there was one outlier in the combined sport activity group who participated in sports more than 10 years since their injury.

The interaction of years participating in sports since onset of disability and activity type on physical domain QOL scores was not significantly different among the levels of time, *F*(6, 162) = 1.458, *p* = .196, 2 = .051. The pattern of difference in physical domain QOL scores among the levels of time were not significantly different among the levels of years participating in sports since onset of disability averaged across activity type, *F*(6, 162) = 1.839, *p* = .095, 2 = .064. The pattern of difference in physical domain QOL scores among the levels of time were not significantly different between the sport activity types averaged across years participating in sports since onset of disability, *F*(2, 162) = 2.759, *p* = .066, 2 = .033. The pattern of difference in physical domain QOL scores among the levels of years participating in sports since onset of disability were significantly different between the sport activity types averaged across time (Figure 32), *F*(3, 81) = 3.734, *p* = .014, 2 = .121. There was not a significant difference in physical domain QOL scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, *F*(2, 162) = .071, *p* = .931, 2 = .001. There was not a significant difference in physical domain QOL scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, *F*(3, 81) = 1.798, *p* = .154, 2 = .062. There was not a significant difference in physical domain QOL scores between the sport activity types averaged across time and years participating in sports since onset of disability, *F*(1, 81) = .623, *p* = .432, 2 = .008.

In order to find the pattern of difference in physical domain QOL scores among the levels of years participating in sports since onset of disability at each level of sport activity type averaged across time, simple main effects of years participating in sports since onset of disability were performed for each sport activity type. The significant differences in physical domain QOL scores among the levels of years participating in sports since onset of disability for those participating in individual sports averaged across time were followed up by post hoc pairwise comparisons of years participating in sports since onset of disability at the individual sport activity type with Bonferroni adjustment. There was a significant difference in physical domain QOL scores among the levels of years participating in sports since onset of disability for those participating in individual sporting events averaged across time, $F(3, 81) = 5.212$, $p = .002$, 2 = .162 (Figure 33). There was not a significant difference in physical domain QOL scores among the levels of years participating in sports since onset of disability for those participating in a combination of sporting events averaged across time, $F(3, 81) = 1.325$, $p = .272$, 2 = .047. For those participating in individual events, the physical domain QOL scores were significantly lower for those who only participated in sports less than one year as opposed to those who participated in sports 1 to 5 years, 5 to 10 years, or more than 10 years averaged across time, $F(1, 81) = 8.734$, $p = .025$, 2 = .097; $F(1, 81) = 7.582$, $p = .044$, 2 = .086; $F(1, 81) = 7.957$, $p = .036$, 2 = .089, respectively. There were no other significant differences in physical domain QOL scores among the years participating in sports since onset of disability for those participating in individual events averaged across time, *p*'s = 1. The means and standard errors for years participating in sports since injury by sport activity type averaged across time are reported in Table 27.

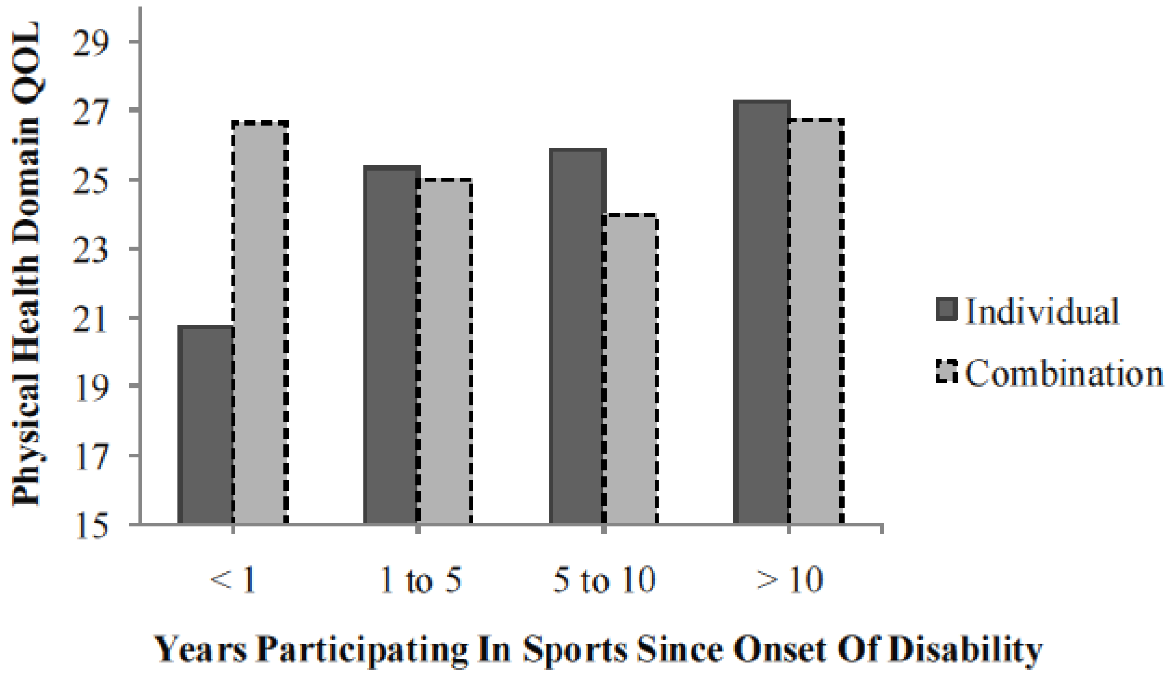

Figure 32. Mean physical health domain QOL scores as a function of years participating in sports since injury and sport activity type.

Table 26. Test of normality of the physical health domain QOL score as a function of time, years participating in sports since onset of disability, and sport activity type.

Time	Years Participating	Activity Type	Shapiro-Wilk *W*	*df*	*p*
pre event	less than 1	individual	.988	18	.996
		combination	.914	9	.344
	1 to 5	individual	.944	12	.553
		combination	.949	7	.720
	5 to 10	individual	.890	7	.277
		combination	.965	13	.822
	greater than 10	individual	.763	4	.051
		combination	.873	19	.016
1 month follow-up	less than 1	individual	.901	18	.059
		combination	.920	9	.390
	1 to 5	individual	.933	12	.415
		combination	.925	7	.509
	5 to 10	individual	.895	7	.304
		combination	.929	13	.331
	greater than 10	individual	.917	4	.519
		combination	.968	19	.741
3 month follow-up	less than 1	individual	.895	18	.048
		combination	.934	9	.516
	1 to 5	individual	.969	12	.895
		combination	.938	7	.620
	5 to 10	individual	.914	7	.421
		combination	.935	13	.399
	greater than 10	individual	.927	4	.574
		combination	.964	19	.647

Table 27. Mean and standard error of physical health domain QOL score as a function of years participating in sports since injury and sport activity type averaged across time.

Years Participating	Activity Type	*N*	*M*	*SE*
less than 1	Individual	18	20.722	.987
	Combination	9	26.630	1.396
1 to 5	Individual	12	25.333	1.209
	Combination	7	25.000	1.582
5 to 10	Individual	7	25.857	1.582
	Combination	13	23.974	1.161
greater than 10	Individual	4	27.250	2.093
	Combination	19	26.719	.960

4.3.4.3 Quality of life (Social health domain) A 3 × 4 × 2 mixed design analysis of variance was performed on social health domain QOL scores as a function of time, years participating in sports since onset of disability, and sport activity type. The within-subject independent variable was time with 3 levels (pre event, 1 month follow-up, and 3 month follow-up). The between-subjects independent variables were years participating in sports since injury with 4 levels (less than 1 year, 1 to 5 years, 5 to 10 years, and more than 10 years) and sport activity type with 2 levels (individual activities and a combination of team and individual activities). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 81.606, F(42, 2072.544) = 1.582, p = .010, Mauchly's W = .318, 22 = 91.774, p < .001. There were violations of normality in 4 of the 24 conditions, Table 28. At the pre event measurement there was one outlier in the combined sport activity group who participated in sports more than 10 years since their injury.

The interaction of years participating in sports since onset of disability and activity type on social health domain QOL scores was not significantly different among the levels of time, *F*(6, 162) = 1.435, *p* = .204, *2* = .050. The pattern of difference in social health domain QOL scores among the levels of time were not significantly different among the levels of years participating in sports since onset of disability averaged across activity type, $F(6, 162) = 1.542$, $p = .167$, 2 = .054. The pattern of difference in social health domain QOL scores among the levels of time were not significantly different between the sport activity types averaged across years participating in sports since onset of disability, $F(2, 162) = 2.932$, $p = .056$, 2 = .035. The pattern of difference in social health domain QOL scores among the levels of years participating in sports since onset of disability were not significantly different between the sport activity types averaged across time, $F(3, 81) = 1.922$, $p = .133$, 2 = .066. There was not a significant difference in social health domain QOL scores among the levels of time averaged across years participating in sports since onset of disability and sport activity type, $F(2, 162) =.364$, $p = .695$, 2 = .004. There was a significant difference in social health domain QOL scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, $F(3, 81) = 3.684$, $p = .015$, 2 = .120. There was not a significant difference in social health domain QOL scores between the sport activity types averaged across time and years participating in sports since onset of disability, $F(1, 81) = 1.497$, $p = .225$, 2 =.018.

In order to find the pattern of difference in social health domain QOL scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The social health domain QOL scores were significantly higher for those who have spent 10 years or more participated in sports since their onset of disability than for those who participated in sports for 1 to 5 years since their onset of disability averaged across time and sport activity type (Figure 33), $F(1, 81) = 7.628$, $p = .043$, 2 = .086. There were no other significant differences in social health domain QOL scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, *p's* > .081. The means and standard errors for years participating in sports since injury averaged across time and sport activity type are reported in Table 29.

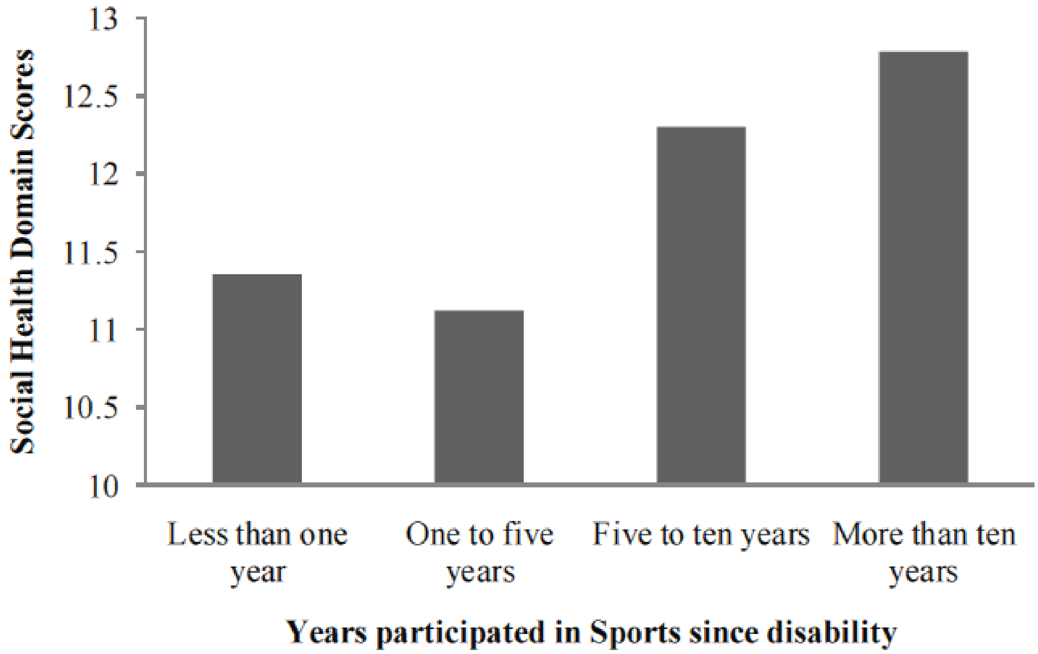

Figure 33. Mean social health domain QOL scores as a function of years participating in sports since injury average across time and sport activity type.

Table 28. Test of normality of the social health domain QOL score as a function of time, years participating in sports since injury, and sport activity type.

Time	Years Participating	Activity Type	Shapiro-Wilk *W*	*df*	*p*
pre event	less than 1	individual	.961	18	.623
		combination	.874	9	.137
	1 to 5	individual	.931	12	.386
		combination	.978	7	.949
	5 to 10	individual	.943	7	.668
		combination	.949	13	.589
	greater than 10	individual	.729	4	.024
		combination	.835	19	.004
1 month follow-up	less than 1	individual	.966	18	.715
		combination	.882	9	.166
	1 to 5	individual	.864	12	.055
		combination	.853	7	.131
	5 to 10	individual	.883	7	.240
		combination	.945	13	.521
	greater than 10	individual	.993	4	.972
		combination	.926	19	.149
3 month follow-up	less than 1	individual	.966	18	.715
		combination	.873	9	.133
	1 to 5	individual	.881	12	.089
		combination	.780	7	.026
	5 to 10	individual	.896	7	.310
		combination	.928	13	.319
	greater than 10	individual	.827	4	.161
		combination	.883	19	.024

Table 29. Mean and standard error of social health domain QOL score as a function of years participating in sports since injury averaged across time and sport activity type.

Years Participating	*N*	*M*	*SE*
less than 1	27	11.352	.338
1 to 5	19	11.121	.394
5 to 10	20	12.300	.388
greater than 10	23	12.785	.456

4.3.4.4 Quality of life (Environmental health domain) A 3 × 4 × 2 mixed design analysis of variance was performed on environmental health domain QOL scores as a function of time, years participating in sports since onset of disability, and sport activity type. The within-subject independent variable was time with 3 levels (pre event, 1 month follow-up, and 3 month follow-up). The between-subjects independent variables were years participating in sports since injury with 4 levels (less than 1 year, 1 to 5 years, 5 to 10 years, and more than 10 years) and sport activity type with 2 levels (individual activities and a combination of team and individual activities). The assumption of homogeneity of variance and homogeneity of covariance were violated, Box's M = 52.549, F(42, 2072.544) = 1.019, p = .438, Mauchly's W = .407, 22 = 71.890, p < .001. There were violations of normality in 2 of the 24 conditions, Table 30. At the pre event measurement there was one outlier in the combined sport activity group who participated in sports less than 1 year since their injury. At each the 1 month follow-up and 3 month follow-up there was one outlier in the combined sport activity group who participated in sports 1 to 5 years since their injury.

The interaction of years participating in sports since onset of disability and activity type on environmental health domain QOL scores was not significantly different among the levels of time, $F(6, 162) = 2.149$, $p = .051$, 2 = .074. The pattern of difference in environmental health domain QOL scores among the levels of time were not significantly different among the levels of years participating in sports since onset of disability averaged across activity type, $F(6, 162) = 1.332$, $p = .246$, 2 = .047. The pattern of difference in environmental health domain QOL scores among the levels of time were not significantly different between the sport activity types averaged across years participating in sports since onset of disability, $F(2, 162) = .477$, $p = .622$, 2 = .006. The pattern of difference in environmental health domain QOL scores among the levels of years participating in sports since onset of disability were not significantly different between the sport activity types averaged across time, $F(3, 81) = 1.451$, $p = .234$, 2 = .051. The pattern of difference in environmental health domain QOL scores was not significantly different among the levels of time averaged across years participating in sports since onset of disability and sport activity type, $F(2, 162) = 4.123$, $p = .058$, 2 = .048. There was a significant difference in environmental health domain QOL scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, $F(3, 81) = 3.763$, $p = .014$, 2 = .122. There was not a significant difference in environmental health domain QOL scores between the sport activity types averaged across time and years participating in sports since onset of disability, $F(1, 81) = .808$, $p = .371$, 2 = .010.

In order to find the pattern of difference in environmental health domain QOL scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, post hoc marginal comparisons were performed with Bonferroni adjustment. The environmental health domain QOL scores were significantly higher for those who have spent 10 years or more participating in sports since their onset of disability than for those who participated in sports for 1 to 5 years since their injury averaged across time and sport activity type (Figure 34), $F(1, 81) = 10.487$, $p = .010$, 2 = .115.There were no other significant differences in environmental health domain QOL scores among the levels of years participating in sports since onset of disability averaged across time and sport activity type, $p > .148$. The means and standard errors for years participating in sports since onset of disability averaged across time and sport activity type are reported in Table 31.

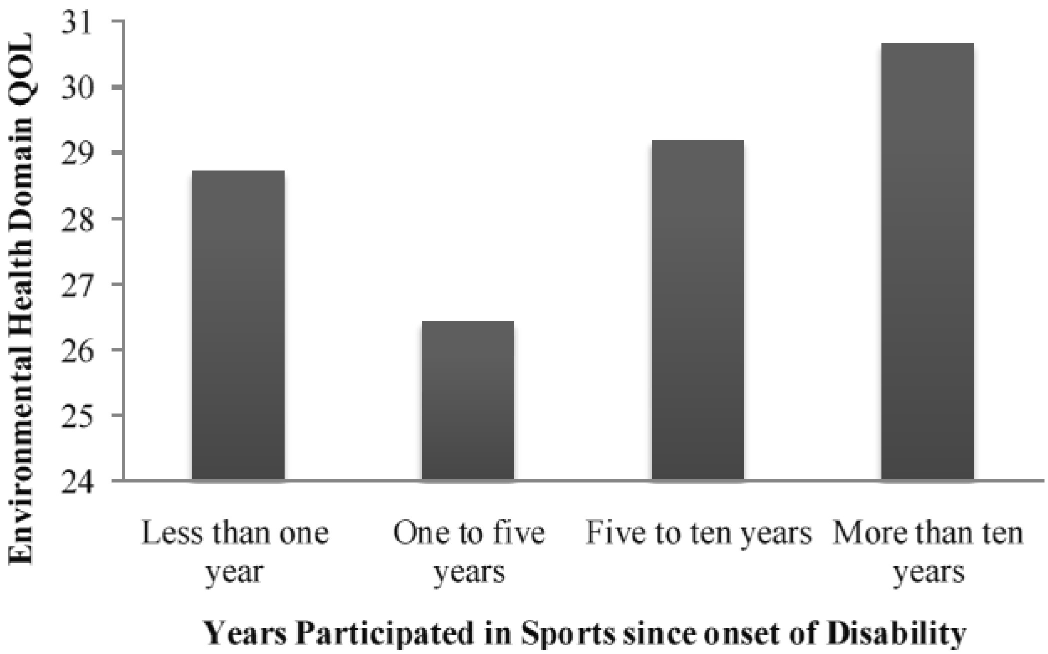

Figure 34. Mean environmental health domain QOL scores as a function of years participating in sports since injury average across time and sport activity type.

Table 30. Test of normality of the environmental health domain QOL score as a function of time, years participating in sports since injury, and sport activity type.

Time	Years Participating	Activity Type	Shapiro-Wilk *W*	*df*	*p*
pre event	less than 1	individual	.962	18	.640
		combination	.847	9	.069
	1 to 5	individual	.955	12	.715
		combination	.932	7	.565
	5 to 10	individual	.914	7	.421
		combination	.964	13	.808
	greater than 10	individual	.791	4	.086
		combination	.931	19	.178
1 month follow-up	less than 1	individual	.984	18	.984
		combination	.927	9	.453
	1 to 5	individual	.930	12	.380
		combination	.697	7	.003
	5 to 10	individual	.932	7	.571
		combination	.915	13	.211
	greater than 10	individual	.972	4	.855
		combination	.923	19	.127
3 month follow-up	less than 1	individual	.988	18	.995
		combination	.927	9	.451
	1 to 5	individual	.956	12	.726
		combination	.803	7	.044
	5 to 10	individual	.951	7	.737
		combination	.955	13	.668
	greater than 10	individual	.878	4	.332
		combination	.955	19	.487

Table 31. Mean and standard error of environmental health domain QOL scores as a function of years participating in sports since injury averaged across time and sport activity type.

Years Participating	*N*	*M*	*SE*
less than 1	27	28.722	.734
1 to 5	19	26.425	.855
5 to 10	20	29.172	.843
greater than 10	23	30.658	.989

4.3.5 Correlations

To further investigate the association of possible confounding factors and the outcomes of interest secondary correlation analyses were conducted. Due to differences in numerical scales of the variables of interest three different correlations were calculated. Pearson correlations were calculated for years the individual has lived with their disability and the study outcomes (Table 32). Polyserial correlations were calculated for years participating in sports since injury (Table 33), and Point-biserial correlations for the intensity of the SER activities (low intensity and high intensity) and the study outcomes (Table 34). Effect sizes and *p* values for the three different correlations are listed below.

Table 32. Pearson correlations between years since injury and the study outcomes.

Psychosocial Outcomes	***r***	***p***
PTGI pre-event	.053	.742
PTGI post-event	.112	.486
PTGI one month	-.162	.312
PTGI three months	-.248	.117
RSES pre-event	.159	.321
RSES post-event	.297	.059
RSES one month	.237	.136
RSES three months	.241	.130
CESD pre-event	-.168	.294
CESD post-event	-.295	.061
CESD one month	-.238	.134
CESD three months	-.234	.140
Physical health QOL pre-event	-.031	.845
Physical health QOL one month	.131	.414
Physical health QOL three months	.143	.372
Social health QOL pre-event	.046	.774
Social health QOL one month	.160	.317
Social health QOL three months	.202	.204
Environmental health QOL pre-event	.031	.848
Environmental health QOL one month	.151	.345
Environmental health QOL three months	.146	.363

Table 33. Polyserial correlations between years participating in sports since injury and the study outcomes.

Psychosocial Outcomes	***p***	***r***
PTGI pre-event	<.001	.354
PTGI post-event	.002	.271
PTGI one month	.003	.287
PTGI three months	.016	.267
RSES pre-event	<.001	.435
RSES post-event	<.001	.596
RSES one month	<.001	.575
RSES three months	<.001	.594
CESD pre-event	<.001	-.444
CESD post-event	<.001	-.477
CESD one month	<.001	-.392
CESD three months	<.001	-.401
Physical health QOL pre-event	.041	.545
Physical health QOL one month	<.001	.417
Physical health QOL three months	<.001	.414
Social health QOL pre-event	.006	.265
Social health QOL one month	<.001	.392
Social health QOL three months	<.001	.495
Environmental health QOL pre-event	.043	.142
Environmental health QOL one month	.008	.342
Environmental health QOL three months	.003	.375

Table 34. Point-biserial correlations between less active and more active sports and the study outcomes.

Psychosocial Outcomes	***r***	***p***
PTGI pre-event	.125	.373
PTGI post-event	.068	.629
PTGI one month	.043	.759
PTGI three month	-.036	.796
RSES pre-event	-.062	.660
RSES post-event	.040	.777
RSES one month	.030	.829
RSES three month	-.058	.681
CESD pre-event	-.094	.503
CESD post-event	.188	.178
CESD one month	.291	.034
CESD three month	.339	.013
Physical health QOL pre-event	-.208	.135
Physical health QOL one month	.001	.993
Physical health QOL three month	-.104	.457
Social health QOL pre-event	-.113	.420
Social health QOL one month	.006	.966
Social health QOL three month	.033	.815
Environmental health QOL pre-event	.018	.896
Environmental health QOL one month	.101	.471
Environmental health QOL three months	.062	.660

4.4 DISCUSSION

With disability statistics rising at a tremendous rate and funding for healthcare being reduced there has never been a more important time to investigate new approaches in order to maximize functional outcomes and improve well-being. While SER as a rehabilitation tool is not a new idea for individuals with disabilities there is a paucity of quantitative evidence to support its use as a primary means of treatment and therefore it is difficult to obtain or maintain funding and resources needed to facilitate well run adaptive sport and recreation programs.

Data for the current study compared the sports participant group to the non-participant group and also analyzed the sport group separately to investigate the effects of years of participation since onset of disability, activity type engaged in, and time among the athletes.

4.4.1 Sports Participants vs. Non-participants

Sports, exercise and recreation participants reported significantly higher self-esteem, posttraumatic growth, and QOL scores along with lower depression scores compared to individuals that did not participate SER.

4.4.1.1 Self-esteem Maslow included self-esteem in his hierarchy of needs and believed that without it people would be unable to grow or achieve self-actualization [91]. Sport, exercise, and recreation has the ability to foster self-esteem in several ways. Firstly, it offers the opportunity to improve ones skills through participation in enjoyable activities. This can lead a sense of mastery of those tasks, which has been closely related with improvements in self-esteem. As the individual develops an improved sense of competence it allows them to see things once viewed as obstacles now as opportunities and take on more difficult challenges. A study by Wann (2006) reported that team identification is also closely related to social well-being, and temporary and enduring social connections provided by participation in SER, especially on a team, are predicted to have a significant impact on psychosocial health and self-esteem [92]. This may have even more pronounced effect on the current study population due to the high number of service members and veterans involved. The military is often regarded as it's own culture defined by camaraderie and esprit de corps. This strong sense of "team" affiliation can be lost when an individual becomes disabled and leaves the military. Sport provides a means to reconnect with ones peers and develop new connections, social support and acceptance.

4.4.1.2 Depression Depressive disorders have been with mankind since the beginning of recorded history. The ability of SER to decrease depression in able-bodied individuals has received much attention in research over the last several decades. While the research studies support a consistent relationship between SER and depression, the mechanisms underlying the antidepressant effects of SER are still poorly understood. Several plausible theories have been proposed such as the distraction hypothesis [93], the endorphin and the monoamine hypothesis [94] among others. However, there is little quantitative evidence to either support or refute most of these theories especially in individuals with disabilities. Participation in SER can provide a situation in which the individual can escape negative thoughts and feelings if only for a short time. This may allow the individual to realize that no matter what issues they may be going through they can still find a place where they can be happy. Social contact may also be an important mechanism in reducing depression, especially when it comes to our study population. Military service members tend to spend a considerable amount of time together and lean on each other in good times and bad. Being removed from this 'family' type environment may cause the individual to withdraw emotionally from society. Another more obvious reason is that improvements in the mobility skills of individuals with physical impairments related to their disability would decrease depressive feelings by increasing accessibility to the world at large.

4.4.1.3 Posttraumatic Growth Trauma has been defined as a threat to psychological integrity, especially cognition [95]. Dr. Tedeschi, the father of posttraumatic growth, has described trauma as, "a shattering of the assumptive world or the way in which one perceives the world around him". It is perceivable that SER allows the individual to connect with things that they have control over and still make sense. Also, following a traumatic disability or on-going chronic illness, some of the individual's life roles (such as employment, disciplinarian, etc…) may be lost temporarily or even permanently. Sport, exercise and recreation can initially help to fill the void of lost life roles and can also evolve into a meaningful part of the person's life such as ongoing participation in adapted sports teams or mentoring other individuals with disabilities. Service members and veterans may look to SER more quickly than civilians to fill those life roles due to it being an integral part of the military life whether they initially want it to be or not. Even those who do not consider themselves 'athletes' before they join the military benefit from participation in one form or another and have a tendency to continue living a more active lifestyle when they separate from the service.

4.4.1.4 Quality of Life The past decade has seen an increasing recognition in the importance of QOL as a crucial measure for subjective well-being in population studies and as an outcome measure in clinical trials [96]. Measuring QOL provides a means by which the respondent's perspective can be placed alongside traditional indicators such as economic growth or medical morbidity [97]. QOL is a complex multifactor concept that has proven difficult to quantify in the past. In the current study we examined three sub-domains physical health, social health, and environmental health as well as overall QOL. We found significantly higher scores in all facets of QOL in the sport participant group when compared to non-participants. The idea that participation in SER improves physical health in able-bodied individuals is well established in the literature and it is no surprise that participation by individuals with disabilities improves scores in self perceived physical health. Sports, exercise and recreation also provides numerous avenues to facilitate and strengthen personal relationships and social interactions. The environmental health domain primarily consists of financial resources, independence, physical safety and security, accessibility and quality of health, the home environment and transport. All of which could be affected by level or severity of handicap. In a study by Manns (1999) it was reported that those who were fitter and more active tend to report a lower level of handicap than their inactive peers [98]. Furthermore, two previous studies conducted by the Human Engineering Research Labs found strong correlations between participation in SER and improvements in QOL and acceptance of the disability [99,100].

4.4.2 Sports Participant Group

4.4.2.1 Self-esteem When controlling for the effects of time and years spent participating in SER since their disability subjects in the sport group reported significant differences in self-esteem scores based on the type of activity they engaged in. Those who participated in a combination of team and individual activities reported significantly higher scores than those who only participated in individual events. A recent study by Laferrier et al. 2011 suggested that the environment created by being surrounded by a group of your peers or your "team" provides the internal support system that helps to foster positive self-esteem [100]. The cohesive group mentality fostered in a team can help to promote many facets related to improving self-esteem. First, it provides a situation where individuals with more recent disabilities can interact and learn from others with similar injuries more distant from date of their disability. Secondly, tasks that may seem nearly impossible when viewed from an individual perspective become less daunting and more enjoyable when surrounded by a team of one's peers. Finally, it allows individuals with disabilities of different types and severity to meet and be competitive on common ground decreasing the overall stigma sometimes associated with having a disability. There was a significant effect found between the number of years someone has participated in SER and the activity type they participated in. Participants that had less than one year of participation in SER following their disability reported significantly lower self-esteem scores than the other three levels of years of participation (1 to 5 five years, 5 to 10 years, or more than 10 years). One possible reason for this finding is that self-esteem is improved through mastery of new skills and the feeling that a task can be completed and the desired outcome obtained. It takes time to develop even an initial comfort level let alone mastery especially if that individual is still learning how to deal with the impairments related to ones disability. Physical self-concept has been linked to self-esteem and depending on the type of disability the individual may still be dealing with body awareness issues [101]. Post-event scores were significantly higher than pre-event scores suggesting a significant positive effect of the SER event. While scores at the one and three month follow-ups regressed slightly below the post-event scores they still remained higher than the pre-event scores. These events were all of short duration, between seven to nine days long, and it would be interesting to see if long term significance would be maintained with interventions of longer duration. Even though there were no other significant differences found between the levels of years of participation the trend showed an increase in self-esteem scores as years of participation increased for those participants engaged in individual activities.

Those participants engaged in a combination of individual and team activities also reported significant differences in self-esteem scores. For these condition individuals that had been participating in SER since their disability for a period of one to five years reported significantly lower self-esteem scores than any other condition. A study by Arango-Lasprilla found that major depressive disorder (MDD) commonly occurs between 1-5 years following disabilities such as spinal cord injury. The high prevalence of MDD may be attributed to dealing with the alteration of life-roles that may occur following disability. While initially the individuals time is spent concentrating on rehabilitation once they return home and settle back into life things may not run as smoothly as they thought. Some roles may have been taking over by others, work performed prior to their disability may no longer be a viable option and the individual with the disability may have a difficult time accepting the situation or themselves.

4.4.2.2 Depression Our current study found significant effects of the number of years of participation in SER since the time of onset of disability as well as time. Significantly lower depression scores were reported by individuals with more years participating in SER since onset of disability. Research studies have shown that depressed patients are less fit and have diminished physical work capacity which in turn may contribute to other physical health problems. These issues can create a negative cascade that increases feelings of hopelessness and depression. Individuals with more years of participation in SER generally have developed an active lifestyle and refined their exercise and recreational regime leading to not only short term but long term benefits of participation in SER including increased mobility and decreased risk of secondary conditions brought on by in activity. As with self-esteem, post-event scores were significantly lower than pre-event supporting a positive effect of the event itself on depression scores and then regressed to non-significance at one and three months.

Craft and Landers (1998) conducted a meta- analysis to investigate moderating factors of exercise on depression. Interestingly, exercise program characteristics such as duration, intensity, frequency, and mode of exercise did not moderate the effect. Only the length of the exercise program was a significant moderator, with programs nine weeks or longer being associated with larger reductions in depression and the effects being maintained for longer periods of time [102]. So it is conceivable that the events selected were not of sufficient duration to provide a significant lasting effect.

4.4.2.3 Posttraumatic Growth There was a significant difference found in posttraumatic growth scores related to the main effects of years of participation since onset of disability and time respectively. Individuals that had participated in SER five to ten years, or ten years or more reported significantly higher posttraumatic growth scores than those who participated in SER or less than 5 years. These findings support the proposition that ‘growth’ does not occur overnight and it takes time to foster that change and this maybe improved through the interactions and experiences offered through continued participation in SER. Interestingly, with regard to time pre-event scores were significantly higher than one and three month follow-up scores but not post event scores. In contrast to resilience, hardiness, optimism, and a sense of coherence, posttraumatic growth refers to a change in people that goes beyond an ability to resist and not be damaged by highly stressful circumstances; it involves a movement beyond pre-trauma levels of adaptation [1]. It could be possible that people who are highest on these dimensions of coping ability will report relatively little growth. Dr. Marty Seligman, professor of psychology and director of the Positive Psychology Center at University of Pennsylvania, believes that there is a bell-shaped curve when it comes to reaction to trauma. “A minority of people develops post-traumatic stress syndrome and anxiety after severe trauma, and another minority experience post-traumatic growth, but the vast majority of people are in the middle. They get over the experience and go back to the way they were before it happened. The ones who grow from it tend to be born optimists” [103].

4.4.2.4 Quality of Life Physical health domain scores were significantly higher for those individuals who had more than one year of experience participating in SER since the onset of their disability if they participated in solely individual activities. Typically those with less than one year of participation in SER are closer to the onset of their disability. It can be postulated that these individuals may not have come to terms with their disability. At this stage they are still learning how to deal with the physical and psychological effects related to their altered functional status thus decreasing their satisfaction with the perception of their physical health. The fact that those who were participating in individual activities reported lower physical health scores with less than one year of experience with SER may be explained by the lack of support to be gained with being surrounded by a team of ones peers. These individuals may initially be fighting through the impairments of their disability either trying to re-learn something they were passionate about before their disability or trying a new activity. These individuals would not be able to fully benefit from the knowledge and experience that is provided by individuals with similar disabilities further from the onset of their disability. This can lead to some of the participants “having to learn the hard way”, and give them a false perception that they are worse off physically than they actually may be.

Social health domain scores remained fairly similar however there was a significant difference found. Individuals who had participated in SER for more than ten years reported significantly higher scores than those who had participated in SER for one to five years. However, there seemed to be a clear delineation with those individuals with less than five years of participation reporting lower scores on the perceived satisfaction with their social health than those with greater than five years of participation although the difference was not significant. As the questions in this domain deal considerably with personal relationships it would stand to reason that prolonged exposure to SER and the positive social characteristics it offers would help to foster new relationships and strengthen those already in place.

4.4.2.5 Correlations In order to further investigate several of the possible confounding variables associated with the significant findings in the study outcomes secondary correlation analyses were performed. Variables chosen included the amount of time the individual has lived with their disability, years of participation in SER since onset of disability, and high intensity activities vs. low intensity activities. It has been theorized that it is not the increased years spent participating in SER that leads to the improvements in psychosocial well-being but simply the ability of the individual to come to terms with their impairments over time and accept their disability as they age. As this is certainly a plausible hypothesis, since you cannot have more than ten years of participation in adaptive SER if you have not had a disability for more than ten years we believed it warranted further analysis. Surprisingly, even though post-event self-esteem and depression were close, none of the correlations based on the amount of time and individual has lived with their disability were significant for any of the levels of the outcome measures. In contrast all of the correlations were significant for the variable of years of participation since onset of disability with moderate to high effect sizes suggesting that it truly was the participation in SER leading to the improvements in the psychosocial outcomes study and not simply the amount of time someone has been living with their disability. For years proponents of competitive sports have stated that high intensity sports and/ or activities such as wheelchair basketball or rugby lead to greater benefits than those of lower intensity such as bowling or billiards. However, our analysis only found significance in two of the 25 outcome conditions suggesting that the psychosocial benefits investigated are more related to the participation in SER itself and not necessarily the type or intensity of the activity.

4.5 CONCLUSION

Adaptive sport, exercise and recreation is not a new idea for individuals with disabilities. Formal physical education and intramural sports programs have been in practice since the 1800's. However its use as powerful, low cost rehabilitation tool is just beginning to be realized. While there is an abundance qualitative support and clinical observations preaching the indelible effects of participation in SER there is still a lack of quantitative support for these claims.

This study attempts to bridge the gap between what medical providers and sports participants believe and what can be supported. Overall, the results from this study support a strong positive effect of participation in SER on self-esteem, depression, posttraumatic growth and QOL.

Several limitations to this study must be noted. First, although not drastic, there was a significant difference between the mean ages of the sports participant group and the non-participant. Second level and severity of disability was not taken into account during the analysis due to the wide variety of physical and cognitive disabilities present in the study population leading to disagreement of level of severity between the two. Third, the control group was recruited primarily from the VA Pittsburgh Healthcare System and Assistive Technology Registry, which could lead to a possible sampling bias. Finally, this was a convenience sample with no randomization of participants.

Even with the limitations listed this is an important move forward in order to provide insight and develop an evidence base related to the multidimensional benefits of participation in SER in a individuals with disabilities population. Future research needs to address potential longitudinal benefits both physiological and psychosocial.

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5.0 CONCLUSIONS AND FUTURE WORK/ INVESTIGATION OF THE PHYSIOLOGICAL AND PSYCHSOCIAL BENEFITS OF PARTICIPATION IN SPORTS, EXERCISE AND RECREATION

Detrimental physical and psychological effects related to disability are well documented in the literature [1-10]. While physiological impairments as a consequence of disability may be readily identified and treated a number of psychosocial issues may receive less attention even though they are every bit as prevalent and damaging. As disability rates continue to rise throughout the population, funding for rehabilitation programs is steadily decreasing and patient stays are getting shorter and shorter [11]. Due to these issues treatment plans may not be as comprehensive as would be considered optimal and patient outcomes may suffer. Medical providers are continually looking for the most effective way to provide the best possible care and maximize patient outcomes.

5.1 CONCLUSIONS

Sport, Exercise and Recreation (SER) have been used to augment rehabilitation programs for decades fueled by quantitative evidence offered in the form of testimonials provided by patients, adaptive sport and recreation participants, and medical providers [12]. While there have been numerous stories of positive life changing experiences related to involvement in adaptive sport and recreation there is a paucity of quantitative evidence to support these claims.

This dissertation attempted to construct the beginnings of an evidence base for the positive psychosocial effects related to participation in SER. The findings of the studies found in the previous chapters reported positive associations of participation in SER on various psychosocial outcomes. The study in chapter two reported a strong positive linear correlation between the number of years of participation in SER and QOL. Higher self-esteem scores were also found to be associated with more years of participation in SER as well as participation in either team sports/events or a combination of individual and team events as opposed to solely individual sports/events. While the study's cross-sectional design made it impossible to infer causality or investigate possible longitudinal effects it still provides a great deal of information related to the topic.

The study in chapter three attempted to correct a number of the limitations found in the previous chapter by using a prospective longitudinal design, recruiting a control group of non-sports participants and adding posttraumatic growth and depression as outcome measures. Sports participants reported significantly better scores on all psychosocial outcome measures when compared to non-sports participants regardless of disability type. Findings were similar to the previous chapter in relation to self-esteem and QOL scores with those participants with more years of experience with SER reporting higher QOL and self-esteem scores. Also in line with the findings of the previous chapter those individuals participating in a combination of individual and team sports/events reported higher self-esteem scores than those who participated in only individual sports/ events. It appeared that number of years of participation in SER positively affected all psychosocial outcomes with those with more years of participation reporting significantly higher scores regardless of time or activity type. While it could be theorized that these higher scores are more a function of people coming to terms with their disabilities over time rather than years of participation in SER secondary correlation analysis between years since disability and all outcomes were not found to be significant, this suggests that it was the years of participation in SER and not simply the years lived with ones disability that are responsible for the better psychosocial outcomes. These studies, while not perfect provide an important step forward in the investigation of the benefits of participation in sport, exercise and rehabilitation.

5.2 FUTURE WORK

This research naturally leads in several directions. Firstly, future work should investigate the longitudinal impact of participation in SER events offered by the VA/ DoD on the physical and psychological health of service members and veterans with varying disabilities. Second, research needs to be conducted on the usage patterns of adaptive SER equipment that has been prescribed and purchased by the VA and its effects on the psychosocial health of its recipients'. Third, assuming the numerous and profound benefits of participation in SER in individuals with disabilities how do we promote those individuals to adopt an active lifestyle?

To address the first issue we propose to collect psychosocial and physiologic data at annual VA/ DOD adaptive sporting events such as the National Veterans Wheelchair Games, The National Veterans Summer Sports Clinic, The National Veterans Winter Sports Clinic, and The Olympic Committee Warrior Games. The study would recruit novice participants and collect data every three months for a period of no less than two years. In addition to the information and psychosocial outcomes currently being collected with SPORTACUS, physiologic data focused on cardiovascular disease risk factors and individualized goals setting will also be collected.

5.2.1 Goal Setting

Goal setting as a process is based on working towards a future outcome. The purpose of rehabilitation is to augment an individual's physical, psychological, and social potential to help the patient accomplish life goals. Life goals are desired states that people seek to obtain maintain or avoid [13]. These goals may influence motivation to participate in the rehabilitation process, re-integrate into the community and improve QOL. Positive well-being has been associated with goals that are specific and challenging [13] much like those that can be achieved through participation in SER. Goal setting and goal attainment are considered to be fundamental parts of rehabilitation. However, goals are individualistic in nature and are motivated by internal and external factors. As such what is important to one individual may not be important at all for someone else. Take employment for example, many studies attempt to ascertain whether or not a specific event or intervention leads to higher rates of employment, but what if employment is not important to the individual and therefore not a motivating factor?

5.2.2 Cardiovascular Health

Cardiovascular disease (CVD) has been the leading cause of death in the United States every year since 1900 except during the 1918 flu epidemic [14]. In 2008 the estimated cost for care of cardiovascular disease in the United States was $448 billion, an increase of approximately $16 billion from 2007 [15]. Over the past four decades, numerous scientific reports have examined the relationships between physical activity, physical fitness, and cardiovascular health. Expert panels, convened by organizations such as the Centers for Disease Control and Prevention (CDC), the American College of Sports Medicine (ACSM), and the American Heart Association (AHA) [14-17] along with the 1996 US Surgeon General's Report on Physical Activity and Health [18] reinforced scientific evidence linking regular physical activity to various measures of cardiovascular health. The consensus is that individuals who engage in at least moderate regular physical activity develop less CVD than their less fit counter parts. CVD has several modifiable and non-modifiable risk factors that have been studied extensively through the years. Modifiable factors include obesity, blood lipid profile, smoking, hypertension, decreased cardio respiratory levels, and stress all of which have all been shown to be positively affected by SER in able-bodied populations [19]. In addition, a growing body of evidence suggests that increasing physical activity can also reduce risk of certain types of cancers, osteoporosis, type II diabetes, depression, obesity and hypertension [19-21]. Rhodes et al. note that regular physical exercise is presently considered to be beneficial in the primary and secondary prevention of about 25 conditions [22]. SER is even more important in individuals with disabilities due to significantly lower energy expenditure (EE). Individuals with disabilities such as SCI may have significantly lower EE than able-bodied individuals due to lower resting metabolic rates (RMR) and decreased thermic effect of activity (TEA), which places these individuals at increased risk for secondary complications (e.g., weight gain, fatigue, pain, and depression) and chronic diseases (e.g., diabetes mellitus and cardiovascular disease) [23]. In a sample of 7,959 veterans with SCI/D, more than two thirds of them are considered overweight based on the adjusted body mass index (BMI) for SCI, including 37% being overweight (BMI between 23 and 27 kg/m^2) and 31% being obese (BMI greater or equal to 28 kg/m^2) [24]. The prevalence rates of asymptomatic CVD in SCI populations range from approximately 25% to more than 50%. The prevalence rates of symptomatic CVD have similarly range from approximately 30% to more than 50%. In contrast, among age-matched able-bodied populations, the prevalence of CVD is typically reported to be in the range of 5–10% [25].

5.3 DATA COLLECTION

5.3.1 Survey Component

Survey data will initially be collected at various events (prior to the beginning of the event and directly following the completion of the event) and then longitudinally at three time points (one, three, and six months) following the initial data collection. The questionnaire will be completed on a laptop computer or in paper format. The following components will be included in the questionnaire: Demographic variables to be collected include age, race, gender, etc. Socioeconomic variables include employment status, years of education, etc. Medical status variables include disability, years of disability, co-morbid conditions, etc. questions related to SER participation before and after disability, goal setting, community re-integration, barriers, and perceived strengths and weaknesses of programs attending.

Self esteem will be measured by the Rosenberg Self-Esteem (RSES). The RSES is a reliable and valid measure consisting of ten statements that ask level of agreement (4-point Likert scale).

The scale ranges from 0-30. A total score is calculated, with a higher score indicating better self-esteem. Scores between 15 and 25 are within normal range; scores below 15 suggest low self-esteem [26].

Quality of life (QOL) will be assessed by using portions of the WHOQOL-BREF. The WHOQOL is a reliable and valid measure developed by the World Health Organization to assess quality of life. The four domain scores denote an individual's perception of quality of life in each particular domain. Domain scores are scaled in a positive direction (i.e. higher scores denote higher quality of life). The mean score of items within each domain is used to calculate the domain score. Two domains, physical health and environment have been selected to be included in our overall assessment of the subjects [18].

Depression will be assessed using the Center for Epidemiologic Studies Depression Scale (CES-D). The CES-D was developed by the National Institute of Mental Health for detecting symptoms of depression. The CES-D measures four domains of depression and has been shown to have good reliability and validity. The CES-D Scale is a 20-item continuous score scale ranging from 0 to 60; higher scores indicate greater levels of depressive symptoms. Traditionally, CES-D scores of 16 or higher indicate significant depressive symptoms, while a score of 22 or higher is considered an indicator of clinical depression [27].

Post-Traumatic Growth (PTG) will be assessed with the Posttraumatic Growth Inventory (PTGI). The PTGI, which assesses PTG measures the degree of change experienced in the aftermath of a traumatic event. PTGI is comprised of five factors: relating to others, new possibilities, personal strength, spiritual change, and appreciation of life, and consists of 21 items. The degree of PTG for each item is rated on a 6-point scale (range, 0-105). Reliability and validity of the PTGI have been verified [28].

Goal Setting evaluation will be conducted by a semi-structured interview in order to develop goals important participant. Progression toward achievement of the predetermined goals will be quantified using a goal attainment scaling (GAS) form.

5.3.2 Physiological Component

Body Mass Index (BMI) has long been considered a major modifiable risk factor for CVD. While some regard body fat percentage (BF %) as the best measure of an individual' fitness level since it is the only body measurement which directly calculates the particular individual's body composition without regard to the individual's height or weight. Deurenberg et al. explored the relationship between densitometrically determined BF% and BMI, taking age and sex into account. Internal and external cross-validation of the prediction formulas showed that they gave valid estimates of body fat in males and females at all ages [29]. BMI will be calculated from an individual's weight divided by the square of the height if expressed in kg/m^2, multiplied by 703 if expressed in lbs/in^2.

Sub maximal oxygen uptake (VO_2 submax) is a widely accepted measure of cardiovascular fitness and aerobic power [30]. Testing will take place using an Arm Cycle Ergometer (ACE) to accommodate those with LE impairment. Oxygen uptake (VO2), carbon dioxide production (VCO2) and expired ventilation (IVE) will be measured min-by-min via a Metabolic Measurement Cart.

Blood Lipid Profile will consist of High density lipoprotein (HDL), Low density lipoprotein (LDL), Triglycerides, Lipoprotien a (Lp(a)), and total cholesterol. This will allow us to calculate LDL/HDL ratio and Total cholesterol/ HDL ratio. Lowering the LDL/HDL ratio is associated with fewer CVD events even in individuals with a high HDL level. The higher total cholesterol/ HDL ratio the greater the risk the goal is to keep the ratio below 5:1 [31].

To address the second issue we propose to partner with the Prosthetic Sensory AS section of the VA and survey all veterans who have received adaptive sport and recreation equipment over the past three years. Data would be collected using a modified SPORTACUS protocol to investigate not only psychosocial and physiologic benefits but also usage, failure and abandonment patterns related to their adaptive sport and recreation technology. Veterans would be instructed that their answers would be anonymous and responses would not affect their ability to obtain assistive technology in the future. Participants would also be asked if they would be willing to join an adaptive sport technology registry and be willing to be contacted in the event of future research.

Finally, to foster the adoption of a healthy lifestyle amongst veterans with disabilities we propose creating a variety of adaptive SER “seasons”. These seasons would be focused on the community and regional levels and provide a variety of sporting and recreation clinics offering exposure and instruction in a number of different sports and activities that take place at the lager VA annual adaptive sporting events. These would then continue as community adaptive sports and recreation programs depending on the level of interest for each activity. Competitions and events would then be held at the local and regional levels at specified times throughout the year culminating at one of the VA annual adaptive sporting events such as the National Veterans Wheelchair Games, Warrior Games or Winter Sports Clinic depending on the activity of choice.

5.4 SIGNIFICANCE

Developing an evidence base to support the benefits of SER will serve multiple purposes. First; it would help to educate medical providers and assist them in developing the most effective treatment plans and rehabilitation programs, allowing them to make the best use of available time and resources. Second, it would provide a knowledge base to educate outside programs, trainers, and coaches as to what is most effective as the majority of these individuals are not medical providers. Third, it would serve to educate third party payers and possibly lead to reimbursement for equipment and services. Fourth, it would provide a means to evaluate the strengths and weaknesses of programs already in use by the VA and DoD. Most importantly it would provide an avenue for Veterans with disabilities to return to a fuller, healthier life.

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