A HOLISTIC APPROACH TO ATHLETIC RECOVERY: A PHYSIO-PSYCHO STUDY

by

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ABSTRACT

The stigma surrounding athletic injuries creates the perception for the athlete that returning to pre-injury status is unattainable. After reviewing the literature, methods of regenerative medicine and psychological interventions are demonstrated to elicit positive outcomes from a rehabilitation standpoint. The goal of this systematic review is to examine the literature to identify regenerative medicine techniques that could be utilized as a conservative alternative to surgery or in addition to surgery. Next, is examining the benefits of human growth hormone as a means to prevent muscular atrophy after surgery. Examining the role of physical therapists in concluding how regenerative medicine and HGH functionally compares to athletes who did not receive these treatments. Finally, considering psychological interventions and methods that could be utilized to limit factors of re-injury anxiety and promote positive cognitive responses to injury. Creating this holistic approach to athletic recovery is designed to create more efficient rehab programs that treat both the physical and mental needs of the athlete, all the while leading to a decreased chance of re-injury.

Keywords: regenerative medicine, human growth hormone, stem-cell therapy, platelet-rich therapy, psychological interventions, self-determination theory, re-injury anxiety, athletes, physical therapy

I. INTRODUCTION TO A PROPOSED CHANGE IN ATHLETIC RECOVERY

Thoughts of early retirement, deciding not to pursue the pros, no scholarship opportunities, are all effects that an injury can create for an athlete. “Is this it”? Feelings of doubt are the spark that lead to an athlete to making the decision to end their career. The stigma that surrounds injuries is the root of these doubts. Therefore, finding a profession that can alter the stigma, that “once you are injured you are never the same” is pivotal for athletes of all ages to believe that an injury does not define their athletic career. Physical therapists are movement specialists, whose role is to prescribe treatment plans, hands-on care, and educate patients (*Becoming a physical therapist*). Physical therapists have the skills and the setting to change lives for an athlete in his or her career. Seeing the patient immediately following surgery the PT provides the basis for physically aiding the athlete’s return to sport, but also can communicate how this injury is going to affect them later in life, as well as teach skills that the athlete can use to help prevent a future injury. A PT is in the ideal position to re-shape habits, training, and lifestyle to help facilitate long-term success and health for the athlete. However, there is room for improvement in order to provide a more holistic approach to athletic recovery. From a surgical perspective, the use of regenerative medicine such as supplementing human growth hormone, platelet rich therapy, and stem cell therapy could yield more efficient and improve long-term outcomes to musculoskeletal injuries. Implementing these treatments could reduce opioid abuse and corticosteroid injections for athletes. The role of physical therapists would be to orchestrate diagnostic tests to evaluate the success and failure of the under-utilized regenerative medicine options. Another holistic approach is

including psychological interventions that reduce re-injury anxiety and provide them with the confidence to believe that the work done during rehab will translate back to a sport-setting. The purpose of this systematic review is to evaluate the literature to find research that can decrease the time out due to injury, better mentally prepare the athlete for return-to-play, and as a result reduce incidents of re-injury at all levels of sport.

II. GROWTH HORMONE AND REGENERATIVE MEDICINE OVERVIEW

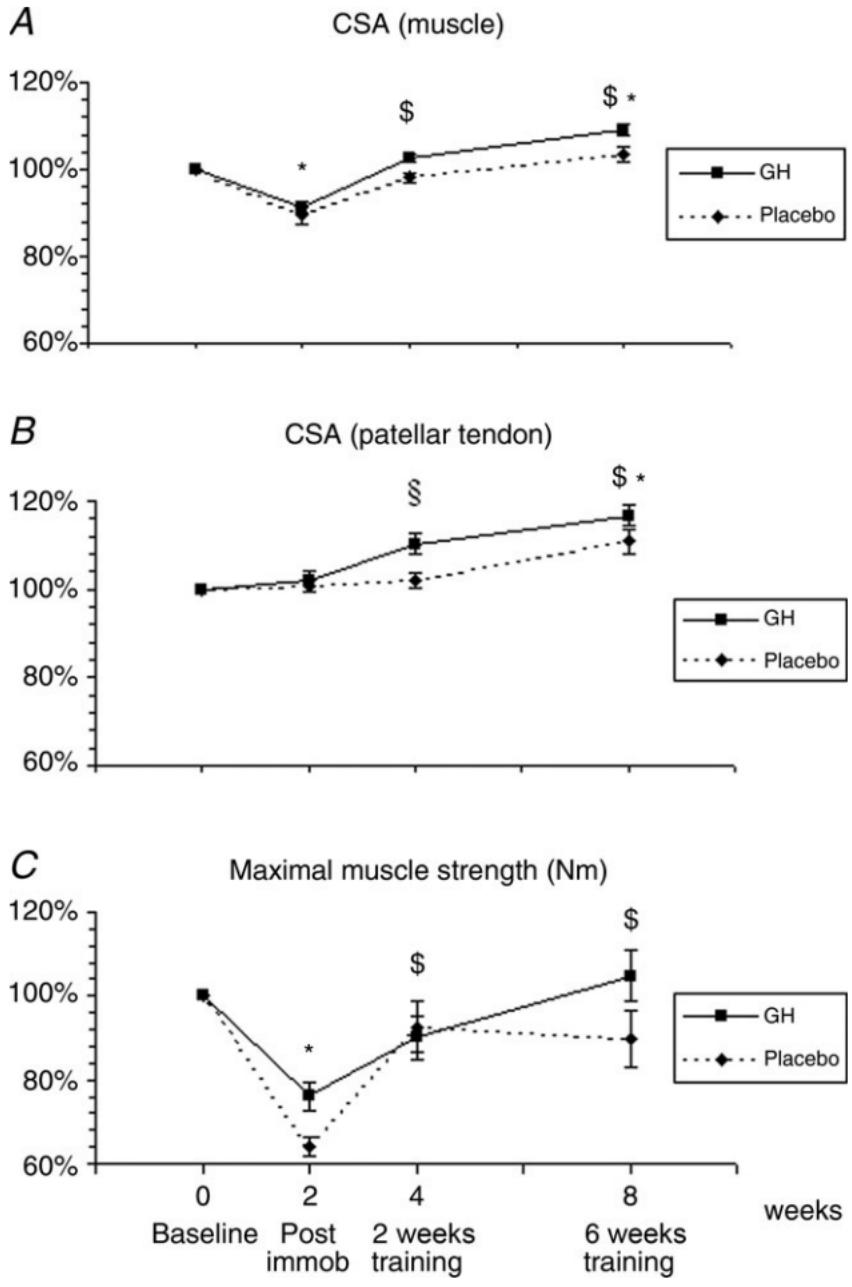
Through the different utilizations of human growth hormone and regenerative medicine techniques have displayed a means to prevent muscle atrophy, to resynthesize soft tissue, and prevent factors that cause degradation of these tissues. Growth hormone is produced naturally in the body and is secreted by the anterior pituitary with the primary function of promoting growth, increasing muscle mass, but also stimulates collagen synthesis for tendons and ligaments (Boeson et al., 2013). The utilization of human growth hormone supplementation in theory, has the capability to increase the commitment of the body's reserve of mesenchymal stem cells (Bolamperti et al., 2019). This ties directly into the use of regenerative medicine which could increase the recruitment of the body's own regenerative agents or supplementing these agents. Regenerative medicine therapies included prolotherapy, platelet rich plasma therapy, and stem cell therapy (Malanga & Nakamura, 2014). The purpose of these sections is to analyze the research that demonstrates how HGH, and regenerative medicine facilitates positive outcomes when implemented prior to surgery or as an alternative to surgery. Then examining and discuss how physical therapists are in an ideal role to prove or disprove these claims from a functional standpoint with the hope that these techniques could be utilized in the future.

III. HUMAN GROWTH HORMONE & PREVENTING MUSCULAR ATROPHY

Human Growth Hormone, when supplemented has shown possibilities of nerve regeneration, stem cell commitment, as well as prevent muscular atrophy due to periods of extended inactivity as with surgery. Boeson et al. (2013) investigate how growth hormone can affect the tendons and skeletal muscle during immobilization and during the steps of rehabilitation. During the study, healthy individuals were immobilized for a two-week period while a clinician administered GH injections to 10 subjects to observe how it affected them versus the control. The findings demonstrated that there were no anabolic effects to the growth hormone administration, but it did prevent loss of muscle mass during the periods of inactivity. At the end of the study IGF-1 activity and tendon stiffness increased which highlights growth hormone's ability to aid not only in preventing muscle loss following surgery, but also preventing tendonous laxity. From a clinical perspective, this could allow for reduced recovery times due to muscular strength not being lost during inactivity. In another study by Doessing and Kjaer (2005) also investigated growth hormones effects on muscular and joint strengthening. Through the methods, dwarf rats underwent an Achilles tendon transection and then were given GH injections to assess whether GH could strengthen connective tissue and reduce strains. GH deficient rats were also given injections in knee tendons and ligaments. Results showed that the rats with the Achilles transection that had GH supplementation and faster functional recovery than that of the control. The GH deficient group showed more efficient collagen turnover which led to better regenerative capabilities than that of the control. Faster functional recovery and increased collagen turnover from a clinical

standpoint could allow for functional training and range of motion needs to be met quicker. ACL testing with the supplementation of HGH exhibited an increase in isokinetic knee extension strength as well as less cartilage breakdown than that of the control group (Mendias et al., 2020). In clinic, this demonstrates how quadriceps strength was maintained following a sedentary period such as surgery as well as the prevention of cartilage breakdown which can occur with sustained periods of inactivity. When supplementing both IGF-1 and GH compared to just GH in male rats following MCL surgery, there was increased max force, stress, and an increase of the elastic region on the stress-strain curve (Provenzano et al., 2007). Demonstrates that there could be a potential need for a combination IGF-1 and GH in order to promote healing of soft tissues. Specifically focusing on REG-03 (a derivative of growth hormone), a study was conducted focusing on 12 rats undergoing an ACL transection and injections of REG-03 were given 14 days after surgery. In comparison to the control, REG-03 improved weight bearing tolerance, decreased cartilage degeneration and matrix when other arthritis medications given in the control did not yield the same results (Montjean et al., 2020). The clinical relevance is evident due to the increase in weight-bearing tolerance as well as preventing cartilage degradation, which can improve pain tolerance through a rehab protocol. Kyparos et al. (2002) suggests that although growth hormone forms greater amounts collagen when supplemented, a repercussion is the fact that growth hormone has been identified to decrease collagen cross-links. As a result, this could lead to a decrease in bone density and should be observed by physical therapists during treatment. Looking at the figure below from Boeson et. al., (2013) examines the relationship that is created

between growth hormone preventing muscular atrophy, maintaining tendon stiffness, and muscular strength through various points of the rehabilitation process.



Human Growth Hormone and Stem Cell Commitment

Growth hormone has a unique capability of shaping the physiological environment, creating a modulatory relationship with mesenchymal stem cells. This

occurs due to growth hormones indirect effect of prohibiting adipose differentiation causing the stimulation of osteogenesis by the recruitment of stem cells. An oversimplification of this process would be that when growth hormone is administered at the site of injury, a signaling response is generated that causes stem cells to increase a protein called osteopontin that increases the production of tissue. A study that observed how implanting a prosthetic limb in rabbits following surgery typically creates a response to surround the prosthetic limb with soft tissue. However, when GH was administered there was greater deposition of bone tissue which indicates a superior osteogenic response than the control (Bolamperti et al., 2013). In theory, the endogenous increase in MSC commitment has the capability to decrease muscular atrophy, increases biochemical signals to promote osteogenesis, and overall quicker recovery times.

IV. NERVE REGENERATION CAPABILITIES OF GROWTH HORMONE

Spinal cord injuries are often career ending at best, and life-changing at worst. Finding methods to recover from these types of injuries is challenging and outcomes are usually subpar. Athletes like Ryan Shazier are the epitome of success when it comes to severe spinal cord injuries, because unlike many others, he is independently walking. A study by Devesa et al. (2011) examines the functional recovery of sciatic nerves with the administration of growth hormone. In the methods, rats underwent a transection of the sciatic nerve that was immediately repaired. Next, growth hormone was administered to half the rats who then underwent treadmill performance tests. Results indicated that the GH group yielded better functional testing than the control. This provides a foundation that GH could be beneficial to athletes or the general population when dealing with spinal

cord injuries and physical therapists can examine the results by functional progressions in rehab.

V. REGENERATIVE MEDICINE AS AN ALTERNATIVE TO SURGERY

The context of regenerative medicine is viewed as the combination of tissue engineering with molecular biology to replace or regenerate human cells, tissues, or organs to restore normal functioning following injury. Regenerative medicine mimics the events that occur during embryonic and fetal development. Injuries that could benefit from regenerative medicine include ligament sprains, conditions that have repair processes such as muscle strains, tendon ruptures, osteochondral injuries, non-union bone fractures, and injuries with little chance of healing such as volumetric muscle loss (Thompson et al., 2016). Research by Malanga and Nakamura (2014) supports the idea that regenerative medicine could prove to be a better alternative to the RICE (Rest, Ice, Compression, and Elevation) when paired with physical therapy which could lead to better non-surgical treatment outcomes. Their Research also suggests that corticosteroids have a negative effect on tendon-to-bone healing and the recruitment of collagen fibrils. Through questionnaires, corticosteroids were reported to provide immediate short term pain relief and then pain returns. While in comparison, regenerative medicine provided longer lasting pain relief. Regenerative medicine techniques fall into three categories; to promote the intrinsic mechanisms of regeneration, supplement the population of regenerative cells, and target features of the pathology that could prevent regeneration (Meyer & Ward, 2016).

VI. TYPES OF REGENERATIVE MEDICINE

Three of the most practiced types of regenerative medicine techniques are prolotherapy, platelet rich plasma, and stem cell therapy. Prolotherapy is designed to issue a healing response by introducing an irritating agent to damaged tissue. The idea is that these agents will cause proliferation of fibroblasts and as a result, deposit collagen. Studies observed this technique treat symptoms of pain in patients with Achilles' tendinosis, plantar fasciitis, and groin pain. In this study the irritating agent was a compound solution of dextrose and sodium morrhuate that was injected every four weeks to elicit a healing response. The outcomes demonstrated an increase in isometric contraction strength 16 weeks after treatment. Next, platelet rich plasma (PRP) is blood plasma with higher amounts of platelet concentration than at baseline. This is designed to promote clotting, inflammation, and healing. The healing component is a result of the presence and release of different growth factors, cytokines, and chemokines that are within the mitochondria. PRP contains serotonin, histamine, dopamine, calcium, and adenosine which contribute to its healing properties. Specifically, serotonin and histamine increase vascular permeability, increasing the number of cells that interact with the inflammation response. The end product is cellular proliferation and the formation of collagen (Malanga & Nakamura 2014). Lastly, stem cell therapy utilizes specialized cells that can differentiate into any types of cell the body needs. Stem cells can be derived from two sources; embryonic stem cells from embryos and adults stem cells which can be found in adipose tissue or bone marrow. Embryonic stem cells have more regenerative capabilities and can divide into any tissue, which labels them as pluripotent. Adult stem cells are more limited in their regenerative capabilities which makes embryonic the ideal candidate for treatment (*Frequently asked questions about stem cell research* 2019).

Looking at the tables below from Malanga and Nakamura, (2014) table 1 highlights the different types of regenerative treatments and their physiological effects that they have on tissue. Next, Table 2 further discusses the growth factors that are released at the cellular level as a result of these treatments and create an environment that is ideal for the healing of various tissues.

Table 1
Various regenerative treatments and their mechanism of action

Treatment	Mechanism of Action
Prolotherapy	Introduce irritating agent Trigger inflammatory cascade Proliferation of fibroblasts, deposition of collagen Healing
Platelet-rich plasma	Degranulation of activated platelets Increased vascular permeability leading to chemotaxis of inflammatory cells Cellular proliferation and formation of extrafibrillar matrix Formation of collagen
Stem cell therapy	Cells differentiate into various cells in the mesenchymal lineage including bone, cartilage, adipose, and other soft tissues

Table 2
Growth factors released from α granules of platelets, and their mechanism of action

Growth Factors Released from α Granules of Platelets	Action
Transforming growth factor β	Mitosis control, activation and differentiation of mesenchymal stem cells, production and secretion of collagen, migration of endothelial cells, angiogenesis, and fibrotic differentiation of skeletal muscle
Platelet-derived growth factor	Stimulates production of growth factors such as IGF-I, in addition to remodeling of tissue
Insulin-like growth factor I (IGF-I)	Migration and multiplication of fibroblasts, which leads to collagen and extracellular matrix protein synthesis
β Fibroblast growth factor	Angiogenesis, cell proliferation, and migration
Vascular endothelial growth factor	Angiogenesis

VII. ORTHOPEDIC INJURY TREATMENTS WITH REGENERATIVE MEDICINE

Focusing on platelet rich therapy and stem cell therapy, there are several orthopedic injuries that could potentially be treated. PRP in muscle strains indicated that muscles treated had better progress, faster return to full function, and an increase in myogenesis. Regarding the knee, a study with cases of patellar tendinosis were treated with PRP injections, 15 days apart. The subjects were seen to have improved function, pain, and perception of physical and emotional health. ACL tears in pigs were treated with a collagen-PRP compound, which stimulated healing observed in the histology and biomechanics. Patients with Achilles tendon ruptures who received PRP had improved ankle mobility and increased efficiency with return to gentle running. The greatest indicator for success of Achilles' patients who received PRP was that their return to pre-injury activities occurred eight weeks sooner than the control. PRP was given to 34 athletes with ulnar collateral ligament tears and joint-space laxity with valgus stress improved. Moving to stem cells, collegiate judo players had 20mm by 20mm lesions of the medial femoral condyle. They were treated with stem cells during surgery and seven months post-treatment the defect was filled with smooth tissue. The biopsy showed layers of hyaline cartilage and chondral bone indicating restorative function due to treatment (Malanga & Nakamura, 2014). Meyer and Ward (2016) support the use of stem cell therapy for chronically torn rotator cuffs. Stem cells aid in creating intrinsic sources of "new" muscle. IGF-1 is used as a signaling response to increase the recruitment of muscle-derived stem cells which is required for intrinsic muscle regeneration. In order to prevent components that promote atrophy of muscle tissue such as myostatin, an

exogenous delivery of growth factors could be administered. Finally, extrinsic sources of "new" muscle such as donor stem cells can be injected into the muscle which functionally assists with regeneration. Next, key components to the outcomes of rotator cuff regeneration relies on physical therapy.

VIII. PHSYICAL THERAPIST'S ROLE IN REGENERATIVE MEDICINE

Physical therapists are trained to manage and treat musculoskeletal pathologies, thereby they have the ability to facilitate healing paired with regenerative medicine (Thompson et al. 2016). An issue with stem cells in chronically torn rotator cuffs is the poor environment for stem cells to proliferate. Fibrosis and fatty infiltration can occupy muscle volume due to stem cells not occupying large amounts of muscle tissue. This along with poor lifestyle traits cause fibrogenic and adipogenic differentiation of stem cells which inhibit regenerative functions. However, following surgery the regenerative demand will be very high, therefore if the signals for myogenesis can overcome the pathological environment, regeneration is possible. Evidence suggests that tendon tears are a progressive injury over time. Physical Therapy will be necessary prior to surgery to create a better environment to prevent fibrosis and fatty deposition. PT is supported due to physical manipulations increasing the effectiveness of regenerative medicine (Meyer & Ward, 2016). Looking towards the future, physical therapists could implement musculoskeletal regenerative rehab which "integrates the principles and approaches from rehabilitation and regenerative medicine, with the ultimate goal of promoting the restoration of function" in clinics. PT's introducing mechanotherapy with regenerative medicine could promote an endogenous stimulation of components to help promote similar responses to that of stem cells. Mechanotransduction is a byproduct of

mechanotherapy, where the stresses that are produced in PT is converted into a cellular and molecular response. Stimuli in therapy such as tension, compression, shear, hydrostatic pressure, and percussion cause cellular responses that result in tissue adaptation. The desired response by PT's is to increase the endogenous commitment of adult stem and progenitor cells. If physical therapy one day focuses on musculoskeletal regenerative rehab, then it will be crucial to be well-versed in how different forces create unique types of cellular differentiation. As a result, this will dictate what tissues are generated by creating rehab programs that provides the ideal force to try and recruit the appropriate stem cells intrinsically (Thompson et al., 2016). The final role of physical therapists is monitoring the mechanical forces and stresses placed on tissues administered with regenerative medicine. Regulating the mechanical features of rehab programs will determine the success or failure of regenerative approaches in the future (Meyer & Ward, 2016).

IX. INTRODUCTION TO PSYCHOLOGICAL NEEDS OF ATHLETIC RECOVERY

Injury needs to be treated physically with surgery and proper rehabilitation, but the psychological aspect of recovery is often neglected for an athlete. Athletes are perceived as invincible, but the general population tends to overlook how immensely impactful an injury can be on one's mental health (Freemantle, A., 2019). As a clinician, taking a holistic approach to the athlete, it is essential to not only repair the body but the mind as well. Examples of athletes can be seen across sports where they are physically cleared to return to sport, but they have an exponential decline in performance. The objective of the following sections is to indicate interventions and strategies to

incorporate a psychological component to an athlete's physical recovery in a post-surgery rehabilitation program.

X. COMPONENTS OF RE-INJURY ANXIETY

A psychological response to injury that is often not thought of in athletes is fear of re-injury, also termed kinesiophobia. This fear of sports-related movement creates a feeling of vulnerability to injury or re-injury after rehabilitation (Christino, Fantry, & Vopat, 2015). It can prevent physically healthy athletes from returning to sport. The stress-injury model observes how stress and anxiety can lead to greater re-injury risks. As a result, when placed in a stressful situation an athlete's judgement of psychological stress can cause muscle fatigue, reduced timing for mental processing, and lack of coordination. Fear of re-injury creates one of the aforementioned perceptions which increases the risk of distractibility, and therefore injury. Athletes with high life stress, increased competitive anxiety, and poor coping mechanisms are at a greater risk of re-injury. It will also be important for clinicians to use diagnostic tools to highlight these traits for an at-risk injury profile. Personality indicators include negative emotionality after completing rehab, trying to slow the end of the rehabilitation process, and hesitation in sport specific drills and tests that the athlete is capable of (Podlog, Dimmock, & Miller, 2011). Medvecky and Nelson (2015) conducted a study of surgically repaired ACL patients, it was observed that not all the patients returned to the sport following surgery. 48 studies revealed that 82% returned to athletic activity, but only 63% returned to pre-injury level of participation. Only 44% returned to competitive sport, showing that kinesiophobia is one of the most common reasons for post-operative decline in sport. As for physical therapy, evaluations towards the end of therapy can be used to find indicators

of kinesiohobia. The next step will be providing physical therapists with the psychological background or bring in sports psychologists to help address the mental block that re-injury anxiety can place on an athlete.

XI. PLAYING WOTH PAIN VERSUS PLAYING WITH INJURY: DISTINGUISHING THE DIFFERENCE

In society, playing through pain is a sign of "mental toughness," those who persevere and finish a sporting event are held in high regard amongst coaches, players, and the fans (Stankovich, C., 2015). However, there is a fine line between playing through pain and playing through injury. In regard to making a decision to play through an injury, there are two major factors; internal and external pressures. Internal pressures come from intrinsic motivators to play the sport, while external pressures come from the desire to win and not be perceived as mentally weak by teammates. Playing through pain occurs in encompasses the athlete listening to their body, decision making, and what individuals have influence over the athlete's decision-making process. Listening to bodily cues can be misleading, due to the fact that athletes can have issues differentiating soreness from pain. In decision-making, there are two criteria. One is examining how impact and consequences of the injury stacks up against dreams and goals of the athlete. In this model, the athlete can focus on the goal and attaining that rather than how severe the injury is or can become if rest and therapy are not implemented. The concluded rationale is that the athlete considers how peers perceive the injury, and that impacts the decision to perform while injured. There is a difficulty internalizing the aspects of long-term injury until the athlete is out for an extended period of time. The second criteria are support versus pressure, where the athlete is traditionally the greatest pressure. The drive

to play through pain as mentioned above, is typically applauded by society, which creates an internal fear of being perceived as weak mentally or physically (Barrette & Harman, 2020). It is imperative as rehab specialists to establish a relationship with the athlete in order to open the floor to discussions about potential injuries in order to address them sooner rather than later. This is more from the perspective a sports medicine team professional or sports-specific physical therapist but implementing strategies to re-shape the athlete's mindset to focus on injury prevention and less on the stigma that surrounds being resilient in the eyes of peers and fans.

XII. INABILITY TO PERFORM AT PRE-INJURY STANDARDS: UNREALISTIC COMPARISONS

Athletes who are presented with an injury, especially who were participating at a high level hold themselves to a high standard. A major component to returning to play is an athlete's desire to reach pre-injury goals. The difference in success and failure can be an all or nothing response for some athletes and finding a way to help re-shape the idea of pre-injury standards or understand how the body is going to have to adapt post-surgery can be challenging (Podlog, L., & Eklund, R. C., 2009). The predominant stressor for athletes seems to originate from the fact they have been unable to perform their skills for a long period of time. This along with a loss of fitness due to a sedentary period, comparing themselves to athletes who have participated in sport following their absence, and the fear of losing technical skill since being out of competition. These fears tend to go away within 6 months of return highlighting importance of performing sport specific protocol in therapy to promote confidence (Podlog, L., Dimmock, J., & Miller, J., 2011). A more optimistic response to injury recovery, is implementing psychological strategies

that associate the injury with “the right path” concept. This implies that the injury has done nothing more than delay the long-term goal, allowing the athlete to refocus their energy to pursuing new goals once they are cleared for play. As an athlete it can be difficult to feel as though you are competing at pre-injury standards. Even if the athlete is performing at a high-level post-rehab, hearing affirmation from individuals the athlete hold in high regard can help their psyche. The ability to remain competitive post-injury and achieve the standard the athlete envisioned through the rehab protocol creates a subjective feeling of satisfaction. This is solidified by praise and positive feedback from coaches displaying that the athlete was missed, is fulfilling a team role, and having success with teammates. An absence of injury-related concerns and staying un-injured is proof that the formerly injured limb can handle the demands of their sport. A final aspect of trying to achieve pre-injury standards is viewing the injury as a life challenge, treating it as a learning experience, and believing that future injuries can be overcome if they are presented (Podlog, L., & Eklund, R. C., 2009).

XIII. ROLE OF SELF-DETERMINATION IN ATHLETIC RECOVERY

A primary psychological theory that showed up in the literature that could be used during an athlete’s return from injury was the incorporation of self-determination theory. The primary philosophy behind self-determination theory is the belief that motivation energizes behavior which in turn affects cognitive, emotional, and behavioral responses related to an injury. The implementation of self-determination is designed for the athlete to reach self-actualization, social development, and meet psychological well-being in a rehab setting. In order for this to occur, the rehab environment must satisfy three needs of the athlete; competence, autonomy, and relatedness. Competence is a sense of ability or

proficiency in whatever activity the athlete engages in (Podlog, L. & Eklund, R.C., 2010). The anxiety that needs to be addressed for the athlete is falling behind competitors due to the injury, diminished post-injury performance, and appearing unskilled or unfit upon return According to Podlog, et al. (2011) there are six steps to meet competence needs. The first is addressing re-injury anxiety by instructing methods of relaxation, imagery, and modeling techniques to form confidence. This confidence can be constructed by looking or talking to athletes who overcame similar injuries. Using modeling decreases feelings of isolation and then relaxation and imagery exercises are suggested to decrease re-injury anxiety. The second is by creating confidence in performance capabilities by providing functional progressive tests in order to replicate game-like scenarios. Using this technique during the rehab protocol during re-evaluations, allows for the opportunity to create and reassess SMART goals for the athlete. The third step is minimizing the influence of self-presentational concerns. Shifting the focus from the perception of how the competition is doing, post-injury performance, and trying to focus on the intrinsic values of the athlete is crucial. This can be evaluated by a self-presentation questionnaire and then after viewing the results, the clinician should try and re-direct the negative self-presentation towards components of self-motivation. Fourth, is providing various forms of social support. Whether that be from you as a clinician, to informing family members what the athlete could need to cope, or even the coach. Fifth, is ensuring the athletes stay involved with sport, and try and develop though re-shaping techniques that remind them that sport is what they do and not who they are. Finally, the last step is reducing return to sport pressures. Having an open conversation with the athlete about risks of pre-mature return is important in order to limit involvement of training and competition. Autonomy

looks at the internal locus of causality and whether the athlete has an internal or external locus of control can often determine how they respond to injury (Podlog, L. & Eklund, R.C., 2010). The literature only discusses issues of autonomy related to external and internal pressures indicate autonomy issues, due to coaches, teammates or oneself attempting to rush recover (Podlog, Dimmock, & Miller, 2011). Relatedness revolves around the sense of interconnectedness with others or social integration amongst the athletes' team, family, and peers (Podlog, L. & Eklund, R.C., 2010). The injury process for an athlete can create feelings of isolation and lack of identity. There is a need to try and maintain a sense of belonging; including social support from coaches, teammates, and significant others in the athlete's life (Podlog, Dimmock, & Miller, 2011). Referencing the self-determination continuum to measure the motivational state of an athlete; it is measured on a scale of amotivation on one end of the spectrum all the way to intrinsic motivation on the other end of the spectrum, with extrinsic motivation in the middle. The goal is to change the way the athlete views the return from injury process and move them towards the intrinsic motivation side of the spectrum. The literature results support the idea that more self-determined athlete will have a greater well-being while more external thinking athletes will have return to sport concerns. Intrinsic motivators have a better assessment of injuries and a renewed sports perspective upon return. Following motivation, it is pertinent to observe appraisals and emotional responses in self-determination theory. Primary appraisals deal with goal relevance, motivation, congruence/incongruence, and ego-involvement. The following are primary due to the vested interest that is required in these aspects of the athlete. Secondary appraisals evaluate response options and coping resources. These consist of blame or

credit, coping potential, and future expectancy of whether the outcome will be positive or negative. In the study from the literature, primary appraisal concluded that self-determination increased linearly as they moved toward intrinsic motivation. Secondary appraisal indicated that coping with injury was feasible and that they would use problem solving and emotionally focused strategies. To conclude self-determination theory, it confirmed that the injured athletes found their return to play exciting as well as threatening, highlights the complexity that some athletes may be fine with the layoff while others may fear re-injury. Secondary appraisal findings indicated that it is important for athletes to have the perception that they are in control of their return to competition, that they can cope with different return plans, and that a positive outcome will eventually occur (Podlog, L., & Eklund, R. C., 2010). Self-determination theory has the capability to be another tool in a physical therapist's arsenal with proper training or having a sports psychologist on hand. Either way, the holistic benefits the athlete can receive from self-determination are remarkable. Looking at the visual below from Podlog, L., Dimmock, J., & Miller, J., (2011) provides an overview of the SDT concerns that need to be addressed during the rehabilitation process.

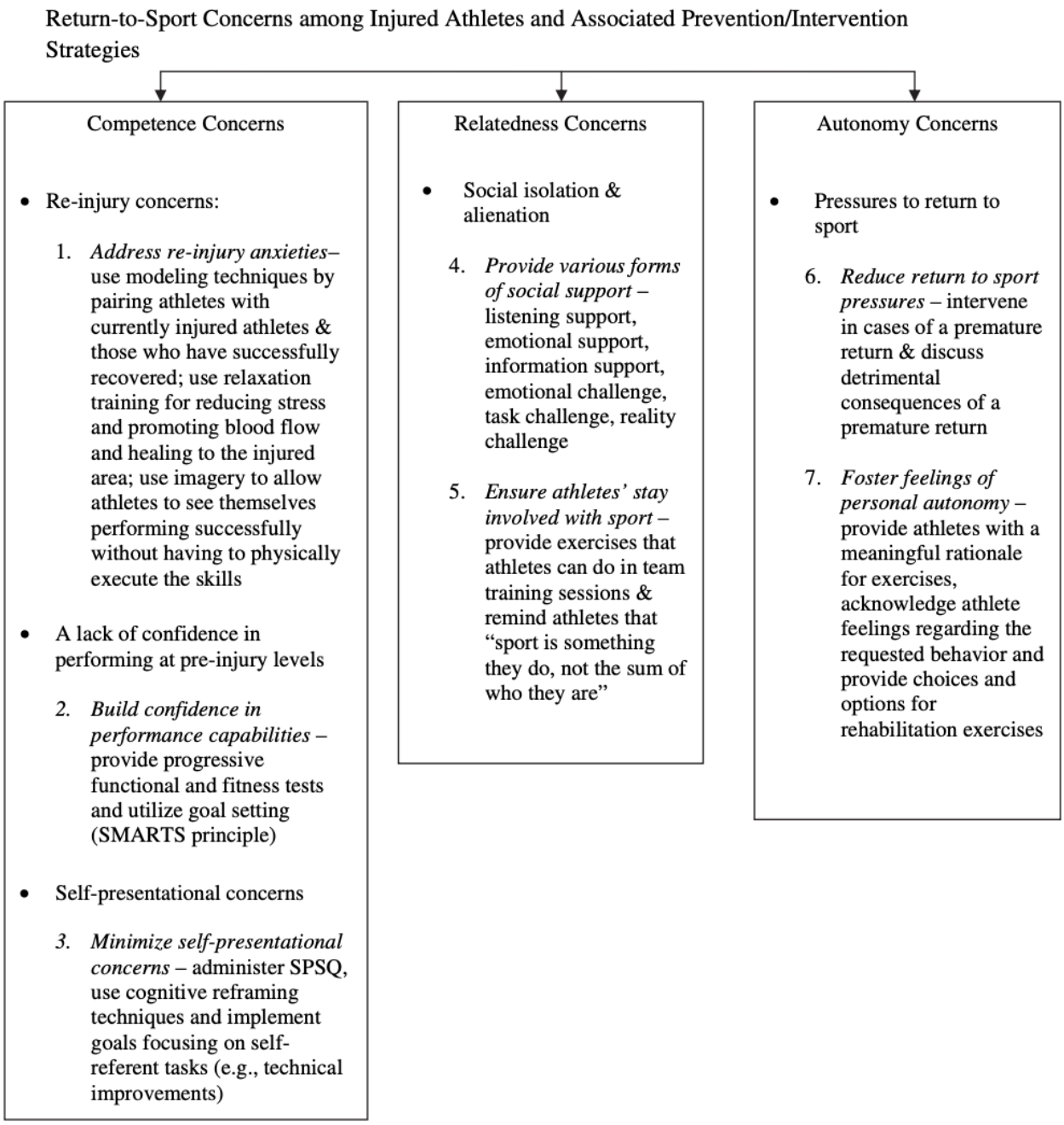


Fig. 2. Return-to-sport concerns among injured athletes and associated prevention/intervention strategies.

XIV. GOAL-SETTING: A STEP-BY-STEP PROCEDURE TO RECOVERY

A primary psychological intervention that is used in a variety of theories and settings is goal-setting. Goal-setting is primarily used as a motivational technique to influence the degree of effort when striving toward a goal. This comes with cognitive effects including;

focusing and directing attention, enhancing persistence, and promoting the development of alternative problem solving. When goal-setting is performed properly, there will be increased effort, improvements in performance, and higher perceptions of success and self-efficacy. A reciprocal relationship is created between goal-setting and self-efficacy, where difficult goals make sure athletes have increased self-efficacy. As a result, athletes will set and achieve more goals. Therefore, further increasing their self-efficacy. The literature identifies three types of goals which are each designated to specific components of the rehab process. These include performance, outcome, and process goals. Outcome goals possess strong motivational factors but involve interpersonal comparison which is hard in an injured population with high anxiety. This requires the athlete to compare his or her goals to others, which depending on where the other person is at in their return from injury can be demoralizing. Performance goals are more effective than outcome goals in terms of a motivational perspective. Process goals are better suited for stressful situations such as an injury, by using perceptions of control and assist in attaining long-term goals (Evans, L., & Hardy, L., 2002). The literature also suggests that there should be levels to goal setting. Long-term goals should promote overall recovery and return to play. Medium-term have stage of healing goals. Finally, short-term encompass day to day aims and objectives (Forsdyke, D., 2014). In the study by Evans & Hardy (2002) goal-setting exhibited an increase in adherence and muscular strength of leg extension in an injured population. Regarding rehabilitation adherence, it correlated to higher self-efficacy, increasing the ability to perform the prescribed rehab protocol. This follows and confirms Bandura's findings of self-efficiency influencing thoughts, behaviors, actions, and emotional arousal. Through surveys and tracking appointment attendance there was a

positive correlation between goal setting and at home exercise adherence as well as effort during appointments. A research study examined 39 knee surgeries who met with a sports psychologist who aimed towards re-evaluating goals. This group had higher exercise adherence rates, as well as higher levels of self-efficiency relative to the control group (Gennarelli, S. M., Brown, S. M., & Mulcahey, M. K., 2020). Physical therapy utilizes goal-setting from the clinician's point of view during the rehabilitation process. However, further incorporating the goal-setting process for the athlete's return to play timeline is shown in the literature to increase motivation, self-efficacy, and help maintain a higher morale through the rehab program.

XV. EFFECTS OF CBT, IMAGERY, COGNITIVE REFRAMING, AND MULTIDISCIPLINARY APPROACHES

Aside from the psychological interventions mentioned above, there are a host of other techniques that could be used to aid in the recovery process of athlete's. Psychological responses to injured athletes changes through rehabilitation. There is a U-shaped emotional response pattern, where negative emotions are high at the beginning of the injury process and then subside through the rehabilitation process and then return after medical clearance (Ardern, C. L., et al, 2012). Knowing how to combat these negative emotions after clearance and addressing them before they occur in rehab is crucial for returning athletic performance to what it was. Within a year of recovery from surgery, about a third of the population meets the criteria of PTSD and depression. Taking preventative measures of identifying athletes at risk of poor outcomes and implementing early interventions to improve recovery. Two interventions were used involving multidisciplinary approaches, including motivational interviewing designed to

coach the athlete towards behavior change and self-management. The other is behavioral activation psychotherapy, which involved pleasant activity scheduling, attempting to relieve sadness related to loss of pre-injury function and avoiding post-injury anxiety. These therapies found a small reduction in the likelihood of having PTSD 12 months post-injury. Over time, the control group seemed to get worse while the treatment group seemed to perform slightly better regarding PTSD, anxiety, and depression. A study examined cognitive therapy, prolonged exposure, and pharmacotherapy (CBT included psychoeducation, muscle relaxation, and cognitive restructuring). Prolonged exposure was utilized in this study to treat PTSD of the injury and was thought that PTSD occurs due to the inability to extinguish fear after trauma. Temporally, CBT had increased effectiveness on PTSD from six months to four years. There were positive outcomes on anxiety and depression at six months post-injury. Providing CBT at a personalized time versus immediately after surgery had a positive impact on reducing the risk of developing psychological conditions. Finally, cognitive therapy played a role in decreasing aspects of PTSD after five months, and anxiety and depression within three to nine months. The results of prolonged exposure played a role of decreasing PTSD within five to nine months and had some effects of decreasing depression at five months. Multidisciplinary and collaborative care interventions found a small reduction in the likelihood of having PTSD at 12 months post injury. The treatment group had better performance outcomes than the control regarding PTSD, anxiety, and depression. CBT, prolonged exposure, and collaborative care interventions within the first four weeks had the greatest effects on PTSD, depression, and anxiety of all interventions (Giummarra, M. J., et al, 2018). A study within the literature observed a case showing at risk rugby players who underwent

a cognitive behavioral stress management program. The intervention group showed less time missed due to injury. Another study looking at college rowers, a stress inoculation intervention was put into place for athletes dealing with life and and competitive stress. Fewer days were missed due to injury within the group that received stress inoculation (Tranaeus, U., Ivarsson, A., & Johnson, U., 2015). Another psychological technique, imagery assists in cognitive and motivational functioning. There are different types of imagery within an injured population. Healing imagery focuses on the process of healing regarding increasing blood flow to tissues. Pain management imagery regulates pain and discomfort as a result of injury which can be a barrier to healing. Rehabilitation process imagery focuses on adherence to protocol, staying positive, and overcoming physical and mental barriers. Finally, performance imagery encompasses practicing techniques with the absence of injury and pain. This is in a sense, a step-by-step process of different types of imagery to use through the whole injury process. A study of 30 ACL patients who used imagery had greater strength and less pain in 24 weeks post-operation with the use of imagery. This proves that if used properly, it can increase speed of recovery, adherence, dealing with relapse, and regulate negative emotions. Finally, the last psychological intervention for athletic recovery to examine is cognitive reframing, which replaces existing negative thoughts with more positive rational thoughts. This causes the individual to focus on less extrinsic thoughts and more on intrinsic reasons of sports involvement. This process is used to recognize negative thoughts, stopping them, and shifting to more positive thoughts (Podlog, L., Dimmock, J., & Miller, J., 2011). These techniques highlight the multifaceted approaches that a physical therapist can incorporate into their rehab program for an athlete. Having a psychological background, allows for a

physical therapist to tap into creative ways to tie in the mental component of sports rehabilitation to the orthopedic concerns that need to be addressed.

XVI. CONCLUSION

Physical therapists must be one of the most adaptive medical professionals in the healthcare industry, and especially when it applies to an athletic population. The purpose of this research was designed to investigate regenerative medicines and psychological interventions that the research had either proven positive outcomes or suggested with more research would lead to better outcomes in the future. Sports rehabilitation is not a one size fits all approach, there is a level of complexity and diversity to how the injury itself manifests, as well as the psychological response that is created by the athlete. Physical therapists are in a prime position to examine the orthopedic outcomes of regenerative medicine, with the hope of implementing it more as a conservative alternative to surgery, or even a co-treatment during surgery. An athlete's psychological response to injury is a result of genetic disposition and sociocultural experiences which creates an interesting challenge of having them mentally prepared to return to sport. The overarching theme of this review is that although sports rehab has come a long way, there are possibilities in the future of designing a more holistic approach to athletic recovery implementing these physio-psycho elements.

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