LEVEL UP PROJECT MODULE

BIOKINETICS SA

LIFE THROUGH MOVEMENT

&

TRIPP

TRANSLATE RESEARCH INTO PRIVATE PRACTICE

Contents

CHAPTER 1 4

Building a robust medical system in Biokinetics 4

1.1 Introduction 4

1.2 Systems thinking for Biokinetic health systems strengthening 5

1.3 Evidence-Based Medicine (EBM) 7

1.4 Interpretation of the evidence 8

1.5 The Evidence Cycle - Duke Program on Teaching Evidence-Based Practice 8

CHAPTER 2 11

The devil is in the detail 11

2.1 Evidence-Based Medicine Program Prescription and Reporting (EBMPPR) 11

2.2 Critical debate in current program prescription 12

2.3 Essence of scientific program prescription 12

2.4 Paradigm shift to more comprehensive rehabilitation prescription 13

CHAPTER 3 15

Load to withstand Load 15

3.1 Define optimal loading 15

3.2 Mechanotherapy: The clinical application of mechanotransduction 17

3.3 Optimal loading within the context of rehabilitation 17

3.3.1 Apply theory in private practice - Physiological Exercise Responses 17

3.4 Optimal loading and return to play 22

3.5 Load specific to the demand (SAID) 23

3.6 Optimal loading and Shared Decision-Making (SDM) 24

Clinical Reasoning Algorithm 26

CHAPTER 5 32

Injury/Illness Risk Management 32

5.1 What is management 32

5.1.1 Step A: Assessment (Initial/Progress) 33

5.1.2 Step B: Reporting on the PROM's, PBOM's and Clinical outcomes (Initial/ Progress) 35

5.1.3 36

CHAPTER 7 44

7.1 Physiological healing thermostat 44

7.1.1 Envelope of function by Dye et al., 1996 44

7.1.2 Mechanotransduction by Khan et al., 2009 44

7.1.3 Physical Stress Theory by Hanse Seyle et al., 1960 44

7.2 Program Format different definitions: 47
7.3 Program content definitions and formulas: 48
7.3.1 Exercise Descriptors 49
7.4.1 Clinical Status Indicator 57
7.4.2 Program adherence over intervention time 58
CHAPTER 8 59
Planning for return to sport 59
8.1 Understand shared decision making (SDM) within the context of multi-disciplinary communication 59
8.1.1 Role definition in sports medicine SDM that includes the three-key people in SDM 60
8.2 StARRT framework as a starting point 61
8.3 Importance of Functional testing in clinical practice 63
8.4 Interpreting the program outcomes measuring methods 64
8.5 Biokineticist role within MD decision-making. 64
CHAPTER 9 66
Why Outcomes, Why Now? 66
9.1 Introduction 66
9.2 Outcomes Measurements 66
9.2.1 Definition of Outcomes assessment: 66
9.2.2 Definition of Outcome Management: 67
9.2.3 Understanding the process of measuring outcomes. 67
9.3 The process of measuring PBOM's and PROM's (Look at the end of page). 68

CHAPTER 1

Building a robust medical system in Biokinetics

Outcomes for module:

1.) **Systems thinking for Biokinetic health systems strengthening**
2.) **Evidence-Based Medicine (EBM)**
3.) **The Evidence Cycle - Duke Program on Teaching Evidence-Based Practice**

1.1 Introduction

Being a Biokineticist in private practice for 18 years, I have spent 12 of those years longing for some form of direction into scientific program prescription. I searched the world and web for direction into the specific application of all the clinical, scientific knowledge that was imparted on me at university level. I was looking for a scientific platform to pitch my new science-mind in such a way that it can bring lasting change unto the current status of patients in front of me. This desire has been a personal rollercoaster ride for the last decade. I needed answers to my questions, namely, what is science and how do I apply science in my practice through scientific program prescription and reporting? This is vital for every Biokineticist to know and execute with every patient, every day. This internal battle carried on for a prolonged time between the two ocean ends of 3x10 repetitions for every therapeutic exercise that I needed to prescribe for individual patients with complex conditions. So, I started to ask questions about my believe system in my mind. I connected my systematic medical solution to a very simple application with no specific format and with no specific measurement of my intervention outcomes within no specific timeframe. Then I asked the question to myself: “Do I need to be so specific?”

Subsequently, an orthopaedic specialist referred a patient to me with a multi-directional shoulder instability and asked me for feedback on conservative treatment vs surgery after 6 weeks of intense rehabilitation. Afterwards I asked myself, how on earth do I need to reply to this specialist within my limited philosophy of scientific program prescription and reporting outcomes measurements. What do I need to report to him so that he will understand and give the patient the best conservative treatment within an evidence base medicine (EBM) shared decision-making process? I immediately tried to conceptualize my answer within my 3x10 belief system and limited outcomes measurements.

This whole process, and much more, started to enable me to think out of the box and to do research into the possibility of developing scientific rehabilitation programs for Biokinetics. Secondary to that, scientific reporting to the multidisciplinary stakeholders.

The challenge at the heart of the module is how we design interventions and evaluate effects, for both health systems strengthening interventions and interventions targeting specific diseases or conditions.

In conclusion, we propose to develop EBM practices through this country and abroad by the application of scientific program prescription/design and reporting, which forms part of the majority of the core value descriptions of being a Biokineticist. The secondary aim of this work is to produce a futuristic stable platform for Biokineticists within the multi-disciplinary team and in the commercial sector through specific reporting intervention outcomes according to the standard of EBM.

1.2 Systems thinking for Biokinetic health systems strengthening

"The responses of many health systems so far have been generally considered inadequate and naïve. ... a system's failure requires a system's solution – not a temporary remedy." (WHO World Health Report, 2008).

“And that is to makes things as simple as possible, but not simpler. Everything needs to have the right level of simplicity, that is not too simple, but not too complicated.”

Prof. Michael Levitt

(Nobel Prize Winner, 2013)

Systems thinking is a management discipline that concerns an understanding of a system by examining the linkages and interactions between the components that comprise the entirety of that defined system. We can then apply this understanding to a safer and more robust intervention design and an evaluation that goes beyond the usual “input-black box-output” paradigm to one that accounts for system behaviour. The systems thinking approach connects intervention design and evaluation more explicitly, both to each other and to the health system framework. The following analogue will shed some light on the system thinking approach that is being proposed.

In fig 1.1 the building blocks alone do not constitute a system, any more than a pile of bricks constitutes a functioning building. The multiple relationships and interactions among the blocks – how one affects and influences the others and is in turn affected by them – convert these blocks into a system.

Using a systems perspective to understand how health (rehabilitation) system building blocks, contexts, and actors act, react and interact with each other is an essential approach in designing and evaluating rehabilitation interventions. A point of concern that needs to be highlighted is the delicate healthcare relationship that exist between exercises interventions, Biokinetic practitioners and patients. This 3-fold connection should have one common goal and that is to accomplish one common objective.



Figure 1.1 Building blocks on its own doesn't constitutes a building

In converting this analogue in the world of Biokinetics: Exercise alone does not constitute a system, it is the functional micro and macro management of the different aspects of an exercise intervention within the conceptual framework of the clinician which resembles an optimal exercise intervention and the ultimate effect of it.

Currently a certain clinical thinking process exists which forms the principal platform for current clinical reasoning in the treatment of patients in Biokinetic practises. This believe system can be termed an open-loop feedback system (Fig 1.2). The main characteristic of this system is that it's mainly driven by the current daily status of the individual patient. In context with the clinical ability of the Biokinetic practitioner, this can be seen as a huge value proposition, but three limitations keep on persisting:

1) This belief can be seen as an unstructured non-systematic rehabilitation approach which can't enable practitioners to plan and project futuristic primary and secondary outcome measurements against the current status of the patient within a certain timeframe.
2) Current approaches don't use scientific program prescription, but rather use a general program planning which lead to oversimplifying complex conditions treatments with uni-modal treatment strategies (3*10 Repetitions).
3) Limited reporting ability on common EBM injury/illness risk measurements.

In this module, it is being proposed to use primarily a closed-loop feedback back system (Fig 1.2). This should enable the clinician to assess EBM patient progression/regression at certain time frames from a pre-estimated timeline. This system will provide the clinician with the following advantages:

1.) Critical clinical information can be withdrawn from small re-assessments that will provide the multi-disciplinary team/patient with valuable primary and secondary outcomes information about the current status of the individual.
2.) This closed-loop system thinking approach can project futuristic situational changes and thus early adjustments can be implemented.
3.) Micro-management of patient is possible through scientific, individual, program prescription based on daily, current status of patient and macro-management through statistical feedback.
4.) Current intervention success/failure can be detected early.

5.) Reporting can be completed at the end of each intervention and minimal clinical important indicators should direct further treatment strategies.

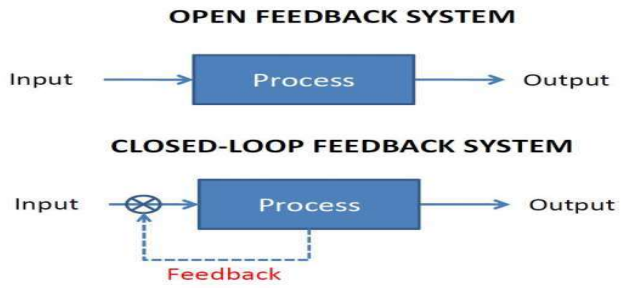


Figure 1.2 Open- and Closed-Loop Feedback System Approach

In conclusion, supplementary to closed-loop system thinking, open-loop thinking can be advocated to keep in touch with the current daily status of the patient. It is being proposed, to use both systems in the format of a continuum within the EBM model (Section1.2), where different amount of weight in the decision-making process will be given, dependable on the patient in front of clinician.

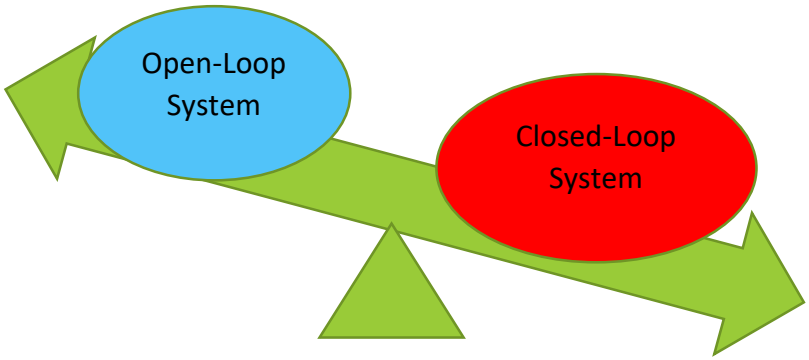


Figure 1.3 Delicate balance between open- and closed-loop systems thinking

Anticipating positive and negative clinical effects within a context of interconnection is key to designing and evaluating a rehabilitation intervention over time.

1.3 Evidence-Based Medicine (EBM)

EBM has become essential for the training of young clinicians by stressing critical thinking and the importance of statistical reasoning and continuous evaluation of medical practice (Swanson et al., 2015).

The most common definition of Evidence-Based Practice (EBP) is from Dr. David Sackett. EBP is “the conscientious, explicit and judicious use of current best evidence in making decisions about the individual patient's care. It means integrating individual clinical expertise with the best available external clinical evidence from systematic research.” (Sackett D, 1996). EBP is the integration of clinical expertise, patient values, and the best research evidence into the decision-making process for patient care. Clinical expertise refers to the clinician’s cumulated experience, education and clinical skills. The patient brings his or her own personal preferences and unique concerns, expectations, and values to the encounter. The best research evidence is usually found in clinically relevant research that has been conducted using sound methodology (Sackett D, 2002).

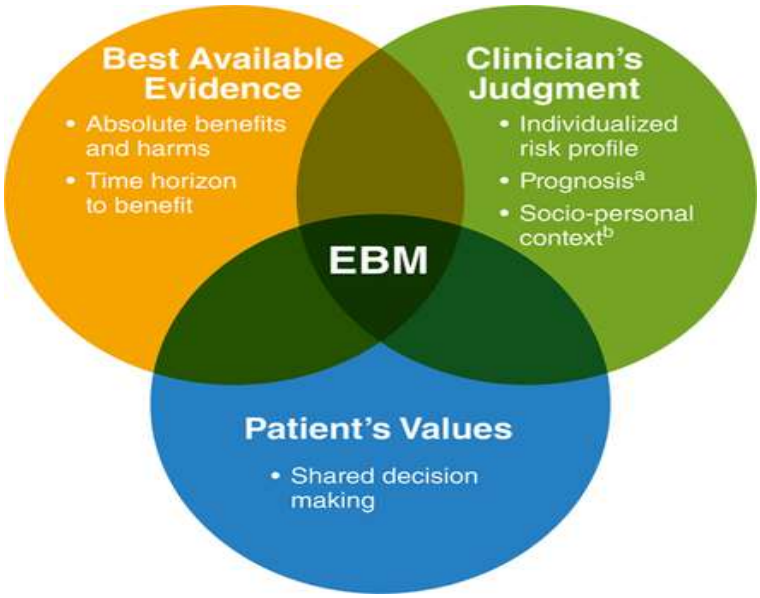


Figure 1.5 Evidence-Based Medicine (EBM) model:

1.4 Interpretation of the evidence

Clinicians need to understand the levels of evidence when considering a particular treatment approach when treating an injured/ill patient. Clinicians need to look for the best available level of evidence for a certain treatment intervention according to EBM practice.

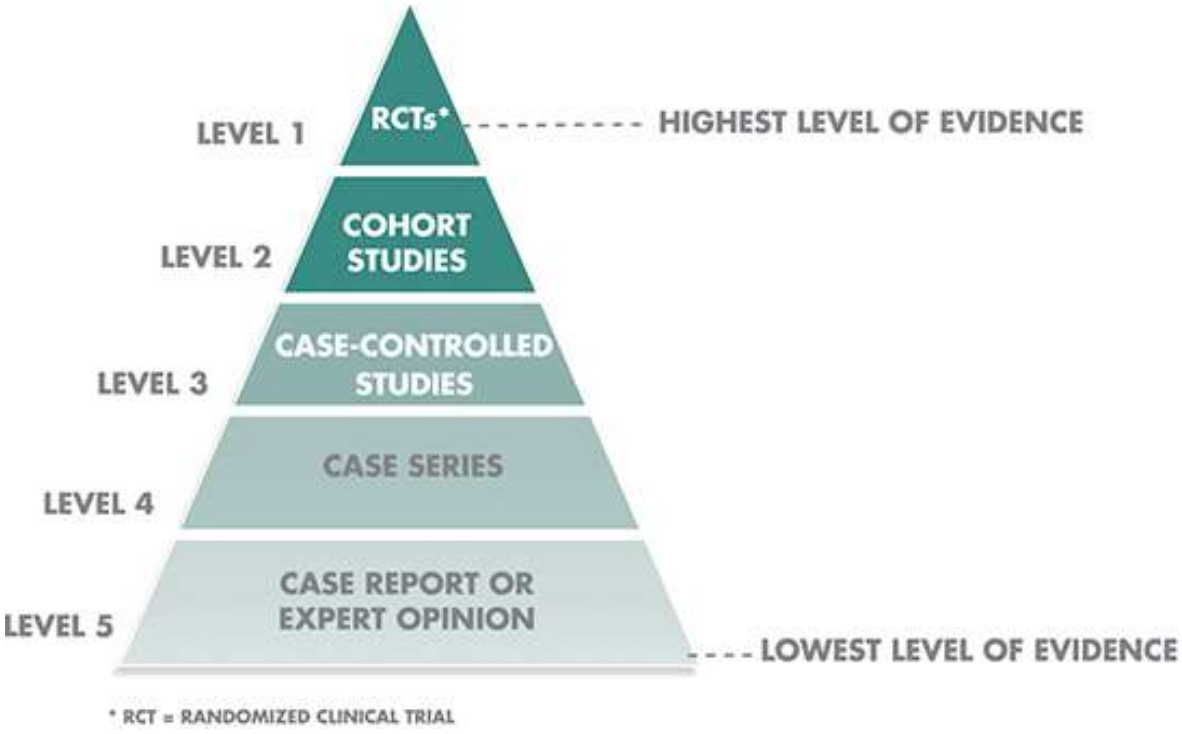


Figure 1.6 Level of evidence and study design

1.5 The Evidence Cycle - Duke Program on Teaching Evidence-Based Practice

The five A's of the Evidence Cycle

Incorporating best evidence into clinical care requires a systematic approach in order to be manageable. A clear series of steps known as the Evidence Cycle can provide an excellent paradigm to guide you through this process. The foundation of evidence-based care remains an excellent clinical evaluation. The clinician must ***ASSESS*** the patient and the problem to determine the pertinent issues, which may include a differential diagnosis, treatment decisions, or prognosis. The clinician must draw from this evaluation and ***ASK*** a clear, answerable question to be pursued.

The next step is to efficiently ***ACQUIRE*** the evidence from an appropriate source. Potential sources include original research studies, systematic reviews, evidence-based journal abstracts, textbooks and computerized decision support systems. With a potential source in hand, the clinician must ***APPRAISE*** the evidence to further examine its worth and reliability. Finally, the process must conclude by returning to the individual patient, as the clinician has to decide whether it is appropriate to ***APPLY*** the evidence to the particular patient and their unique values and circumstances. Evidence alone is never sufficient to direct decision-making. Rather, it must be put into context with a patient's values.

ASSESS: Clinical Evaluation

The method of evidence-based clinical practice (EBCP) begins with a thoughtful assessment by a clinician who incorporates all the pertinent data. A common fallacy is that EBCP somehow devalues the fundamental tenets of the practice of medicine, specifically clinical expertise. A comprehensive understanding of pathophysiology and the thorough history and physical remain a critical starting point for the process.

ASK: Clinical Question Development

The first critical step is to clarify one or two key issues that come up in the course of caring for your patient and to develop a focused clinical question. Despite its critical place at the start of the evidence cycle, question development is often not a focus of training. In a recent survey of 417 internal medicine program directors, only 44% of programs with evidence-based medicine curricula included posing a focused question as an objective. However, without this critical first step, the rest of the steps are immaterial.

The Anatomy of the Clinical Question (PICO)

One useful approach to framing a clinical question involves distilling the question into several key elements. In this framework, there are 4 components to every clinical question, the **P**atient population, **I**ntervention, **C**omparison and **O**utcome (**PICO**). We can use this framework to clarify the steps that we must take to find the evidence we seek.

ACQUIRE: Searching for the Evidence

Armed with our well-built clinical questions, our attention then turns to finding the evidence in the medical literature. Many resources are currently available; therefore we must learn to appreciate the pros and cons of each type to determine when each one can best be applied. We also have to learn how to access resources that can maximize our efficiency, such as a systematic review, clinical practice guidelines or an evidence-based journal abstract.

APPRAISE: Critical Appraisal of the Evidence

Much of the initial attention in the realm of evidence-based medicine focused on the critical appraisal portion of the evidence cycle. A growing body of resources exists in various print and electronic formats to aid readers of the medical literature in the critical appraisal process.

APPLY: Applying Evidence to the Patient

Every management decision requires value-laden deliberation and judgment. Each piece of evidence that we review adds something to our understanding of our patient's situation. However, we need to consider how to generalize the results from clinical trials to our individual patient. We must consider whether the patient populations and treatments or interventions are comparable to our setting. The final challenge is to combine the evidence and clinical expertise with compassion and patient values. Clinicians trying to engage the medical literature for best care must take the information from these studies to try to help individuals within the context of their own values and preferences.

CHAPTER 2

The devil is in the detail

Outcomes for module:

1. **Evidence-Based Medicine Program Prescription and Reporting (EBMPPR)**
2. **Critical debate in current program prescription**
3. **Essence of scientific program prescription**
4. **Paradigm shift to a more comprehensive program prescription**

2.1 Evidence-Based Medicine Program Prescription and Reporting (EBMPPR)

EBMPPR can be conceptualized as a practice that focuses on the continual micro and macro exercise adjustments a clinician needs to make within an exercise program to fit the ever-changing profile of the individual patient. The overall clinical effect of the management of the different variables within a program can be reported on within a solid platform. The benefit effect of this will be translated on 3 different levels, namely:

1. Multi-Disciplinary Shared Decision Making will benefit to whether the intervention was successful or not.
2. Information will notify current clinician about further treatment while considering the effect of previous treatment.
3. Patient will stay motivated to the desired treatment by continual feedback from the clinician.

Current program prescription follows the layout of the ACSM which can be seen as general guidelines for program prescription (Garber *et al.,* 2011).

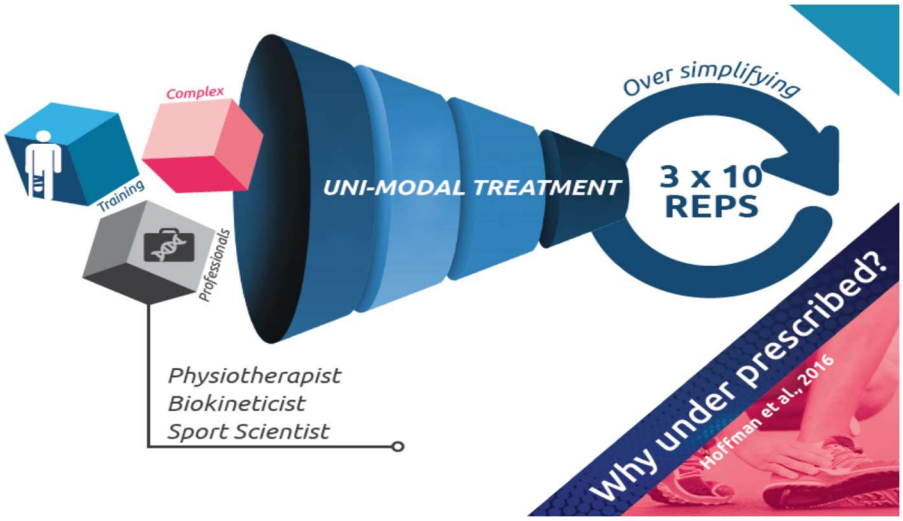


Figure 2.1 Complex training versus over simplifying treatment

2.2 Critical debate in current program prescription

Current program prescription lacks the specificity of certain program variables (tempo, adherence to intervention, load magnitude, etc.). The consequence of this is that certain complex multi-factorial conditions can currently only be treated through a very simplified general model without specified documented outcomes measures (Fig 2.1). The risk involve in such an approach could be the misinterpretation or even no interpretation of the effectiveness of the prescribed intervention and the communication of the effect to other shared decisionmakers. In a systematic review done by Hoffman et al. (2016), exercise intervention is under prescribed and frequently overlooked, often in favour of a pharmacologic or surgical intervention.

Why under prescribed:

1. Clinicians/patients lack in awareness of the positive effect of exercise interventions.
2. Poor knowledge about what encompasses an effective exercise intervention.
3. Inadequate descriptions of exercise interventions in published trials and reviews.

It was concluded by the same group that “To prescribe exercise for chronic/orthopaedic conditions, clinicians must know sufficient details about the appropriate and effective exercise interventions and their components” (Hoffmann et al., 2014).

2.3 Essence of scientific program prescription

When we use the words scientific programme prescription, we need to define the word scientific. The root word is science which means according to the Oxford Dictionary: ”A systematically organized body of knowledge on a particular subject”. Scientifically means “scientific methods and principles”. ***In summery scientific program prescription/design within the context of exercise therapy can be translated into exact medical treatment provided to patients through scientific methods and principals.***

The essence of scientific program prescription can be summarized in the following statement: “It is written for a specific purpose with specific outcomes, within a specific format, while considering a specific timeframe.” This approach will enable the Biokineticist to provide detailed documented results about the exercise intervention. The chain effect of this will be improved patient management throughout the multi-disciplinary communication channels.

2.4 Paradigm shift to more comprehensive rehabilitation prescription

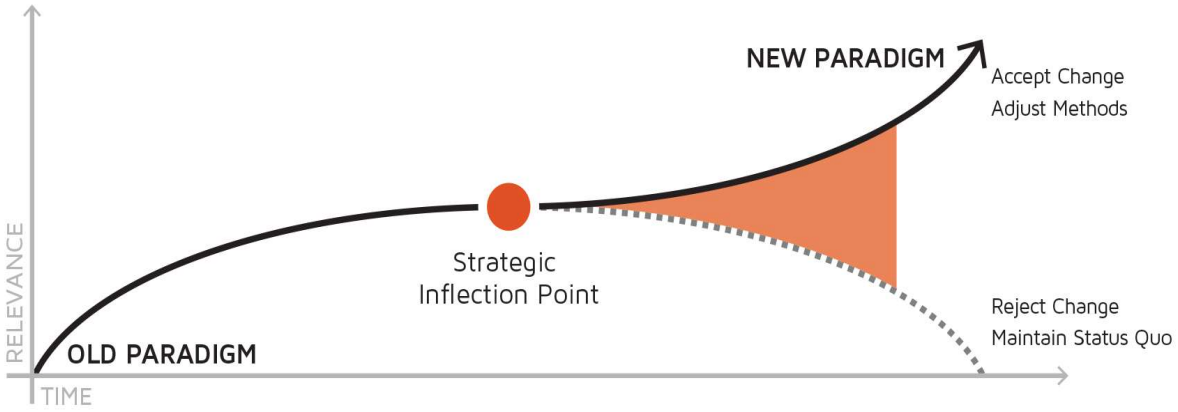


Figure 2.2 A strategic inflection point is a time period when an organization must respond to disruptive change in the business environment effectively or face deterioration.

In a systematic review been done by Slade et al., (2012), Seventy-one percent of reviews reported being unable to adequately describe the exercise programmes, because the required information was not reported in included trials.

Facing an extraordinary demand or opportunity for which there are no easy answers often signals that the tide is turning — one phase is ending, while something new is struggling to emerge. In pursuing the new phase, a paradigm shift seems to be the answer.

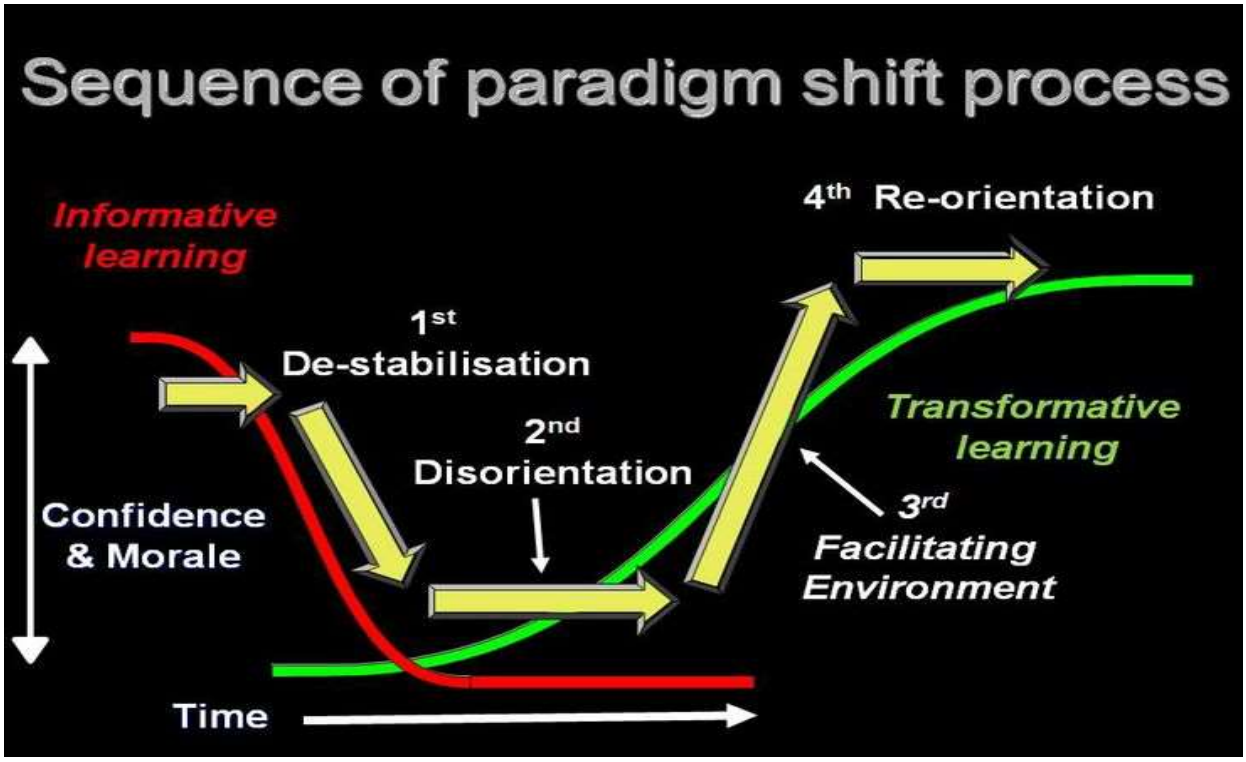


Figure 2.3 Process of a paradigm shift

A paradigm shift could be defined as a process which starts with some informative learning information. Individual current thinking processes are being challenged. Confidence and morals decrease and candidate can sense some form of destabilisation and disorientation in this new

environment. Through time a new environment will be facilitated and the process will end where the learner will experience transforming learning skill that can be applied readily.

A paradigm shift to a more comprehensive program prescription has been proposed where the clinician could have the benefit of documenting the program variables of importance for any specific condition as dictated by research and thus result in quality EBM decisions*.*

This approach will lead to the maturation of the Biokinetic profession as an entity within the core value of our scope of practice. This type of scientific platform will provide us with a strong voice of "exercise is medicine" within the industry on international level.

References

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., … Swain, D. P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine and Science in Sports and Exercise*, *43*(7), 1334–1359. https://doi.org/10.1249/MSS.0b013e318213fefb

Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., … Michie, S. (2014). Better reporting of interventions: Template for intervention description and replication (TIDieR) checklist and guide. *BMJ (Online)*, *348*(March), 1–12. https://doi.org/10.1136/bmj.g1687

CHAPTER 3

Load to withstand Load

Outcomes for module:

1. **Define optimal loading**
2. **Mechanotherapy: The clinical application of mechanotransduction**
3. **Optimal loading within the context of rehabilitation**
4. **Optimal loading and return to play**
5. **Load specific to the demand (SAID)**
6. **Optimal loading and shared decision-making**

3.1 Define optimal loading

Optimal loading may be defined as the load applied to structures that maximises physiological adaptation while maintaining homeostasis on systemic as well as non-systemic physiological levels. Achieving optimal loading is challenging but should be driven by variables such as the tissue type, pathological presentation, chronic condition and the required tissue adaptation for eventual activity. Specific loading goals may include increased tensile strength, collagen reorganisation, increased muscle–tendon unit stiffness, neural reorganisation or improve cardiovascular fitness (Glasgow, Phillips, & Bleakley, 2015).

While not a cure, exercise is an intervention that has a role to play in every aspect of physical activity and exercise medicine. In a sense, our first question when considering treatment options should be, ‘What type of exercise should I prescribe?’ rather than ‘Should I prescribe exercise?’. But what guides our decision-making in determining the nature, type and volume of exercise for patients? As with anything we prescribe, we should seek to ensure that we prescribe for the greatest therapeutic benefit and tailor it to the needs of each individual.

Karim Khan specify the need to follow the algorithm from Aspetar group to understand the “why” we do a certain exercise, “what” exercise do we specifically prescribed to take care of the specific problem and then “how” do we execute the specific exercise to accomplishes a certain goal (Fig 3.2). All of the above mentioned was in line with the CERT, 2017(Attached) and the Toigo and Boutellier, 2006 proposal for scientific prescription of exercise interventions.

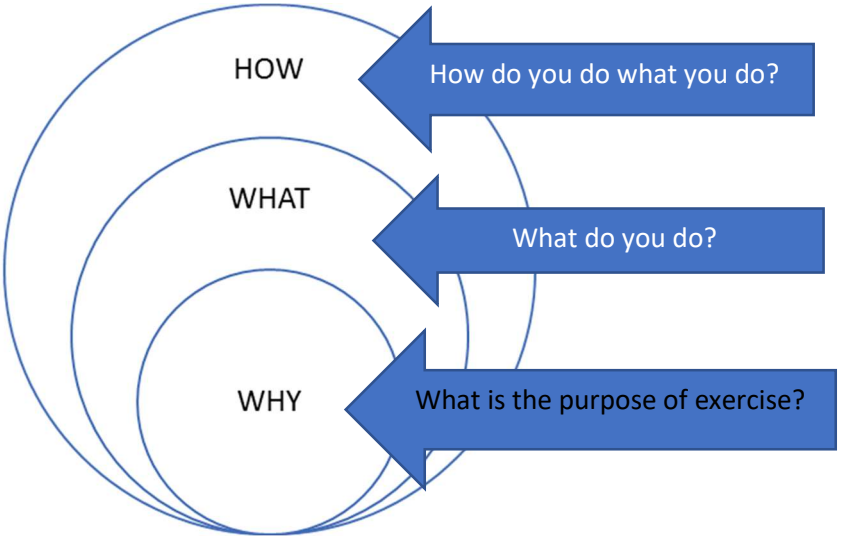


Figure 3.1 Research considerations according to the Optimal Loading Congress, 2017

Research directs clinical practice to the importance of scientific program prescription and the documentation of all the variables (Fig 3.2) that need to be included in a scientific exercise intervention (Slade *et al.,* 2016). It was proposed from the Oslo injury prevention platform that research needs to be translated into private practice. It should follow a layout of practicality and time efficiency to enable practitioners to duplicate research results in their clinical practices.

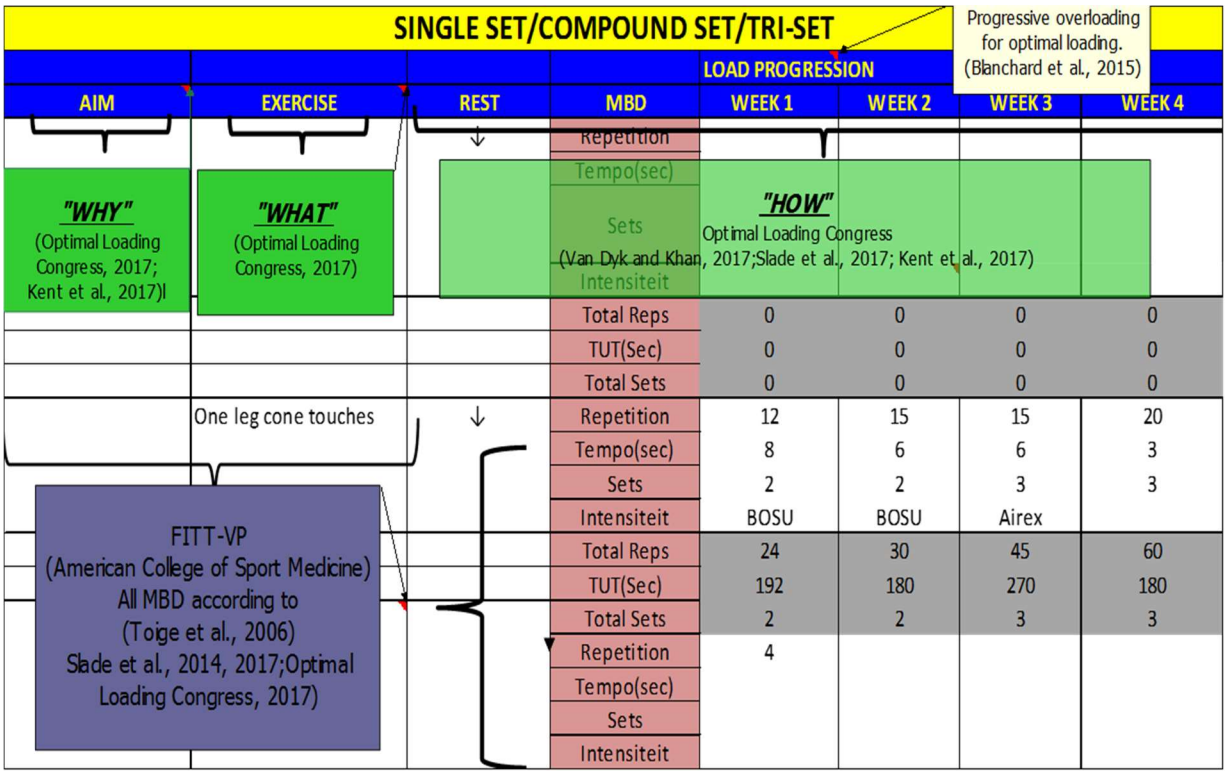


Figure 3.2 Understanding the evidence behind scientific program prescription

3.2 Mechanotherapy: The clinical application of mechanotransduction

The need to highlight the importance of mechanotherapy lays at the heart of this module because that is what exercise as an intervention is about. The important understanding of the why we do a certain exercise should be conceptualized in the definition of mechanotherapy. Mechanotherapy can be define as the process by which the body converts mechanical loading into cellular responses and have a close relationship with the term meganobiology (Fig 3.3). Meganobiology can be defined as the physical forces and changes in cell or tissue mechanics that can contribute to the development of optimal physiology or pathology in any structure (Thompson et al., 2012). These cellular responses, in turn, promote structural change (Khan & Scott, 2009). Controlled loading can enhance healing in most settings; however, a fine balance must be reached between loads that are too low (leading to a catabolic state) and too high (leading to micro-damage) (Killian et al.,2012).

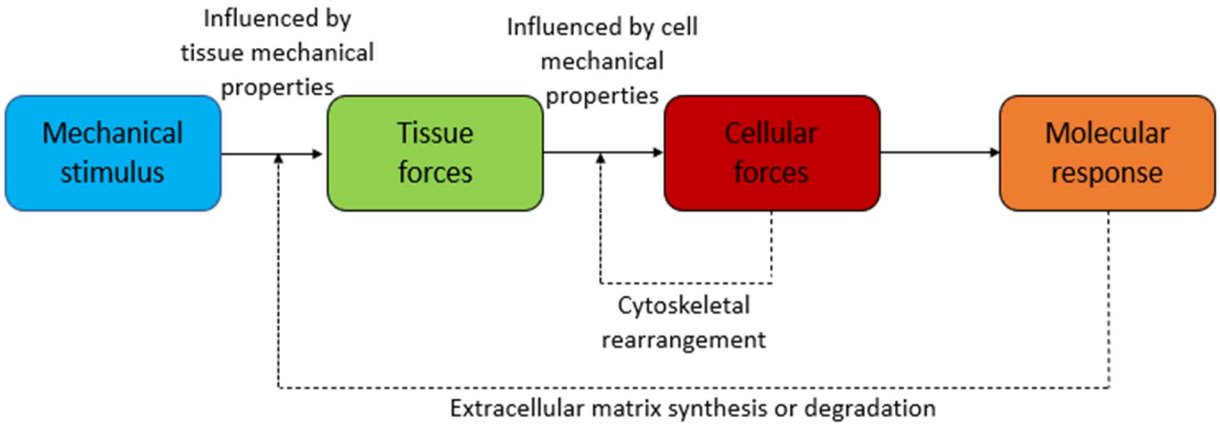


Figure 3.3 Understanding Mechanobiology (Thompson et al., 2015)

Mechanical forces direct cellular activities to induce tissue adaptation. Extrinsically and intrinsically generated mechanical forces load musculoskeletal tissues, with the characteristics of the resultant tissue forces being dependent on the ability of the tissue to resist those forces. Tissue forces are transmitted to the micromechanical environment of resident cells, with cellular mechanical properties, influencing the characteristics of the cellular forces. Cells can modify their micromechanical environment via cytoskeletal rearrangement, which feeds back to alter cellular sensitivity to incoming forces. When cellular forces are sufficient, the cell initiates a molecular response, which ultimately alters synthesis or degradation of the extracellular matrix. The latter alters tissue mechanical properties, which feeds back to influence tissue forces (Fig 3.3) (Thomson et al., 2015).

3.3 Optimal loading within the context of rehabilitation

3.3.1 Apply theory in private practice - Physiological Exercise Responses

The adaptation's specificity depends on the distinct molecular and cellular events triggered by unique combinations of conditional cues. In order to derive effective and tailored exercise prescriptions, it must be determined (1) which mechano-biological condition leads to what molecular/cellular response, and

(2) how this molecular/cellular response relates to the structural, contractile, and metabolic adaptation (Toigo & Boutellier, 2006).

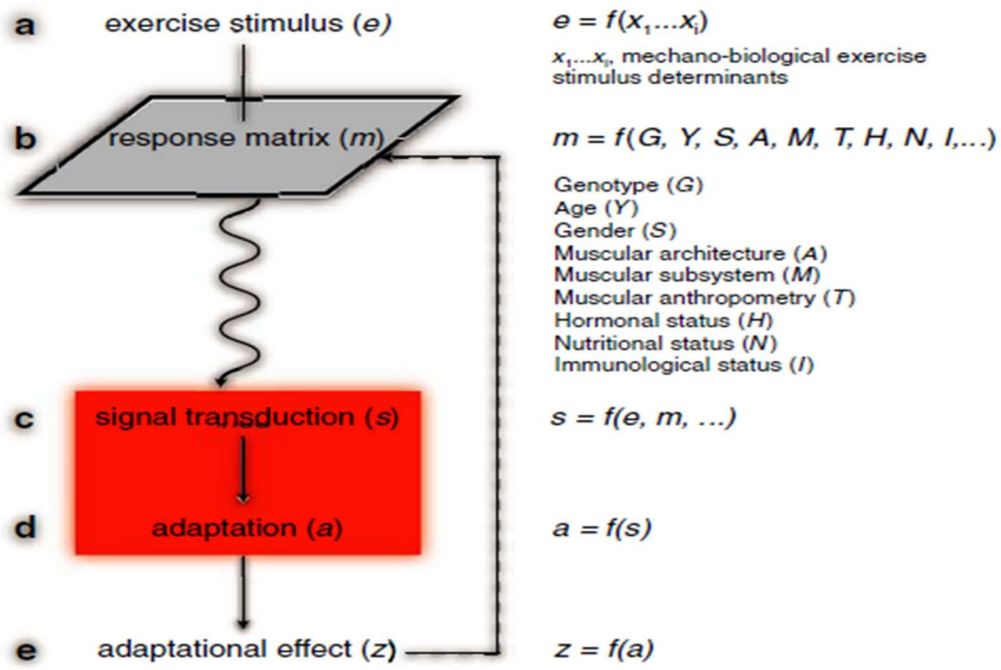


Figure 3.3 Simplified model for the transduction of exercise-related skeletal muscle perturbations into structural adaptations with associated adaptational effect. An exercise stimulus with defined mechano-biological characteristics (Reps, Sets, Load magnitude, Rest ect.) (a) is mechano-chemically transduced (c) into a quantitative and/or qualitative adaptation (d) of the muscle phenotype, based on the respective response matrix (b). The adaptation (d) is associated with the corresponding adaptational effect (e). A causal connection exists between (c) and (d) (red shading).

The physiological adaptational effect will follow Wolf's Law and Davis Law's of adaptation according to the SAID prinsipal. Wolff's law, developed by the German anatomist and surgeon Julius Wolff (1836–1902) in the 19th century, states that bone in a healthy person or animal will adapt to the loads under which it is placed. If loading on a particular bone increases, the bone will remodel itself over time to become stronger to resist that sort of loading. Davis's law is used in anatomy and physiology to describe how soft tissue models adapts to imposed demands. It is the corollary to Wolff's law, which applies to osseous tissue. It is a physiological principle stating that soft tissue heal according to the manner in which they are mechanically stressed (Fig.3.4).

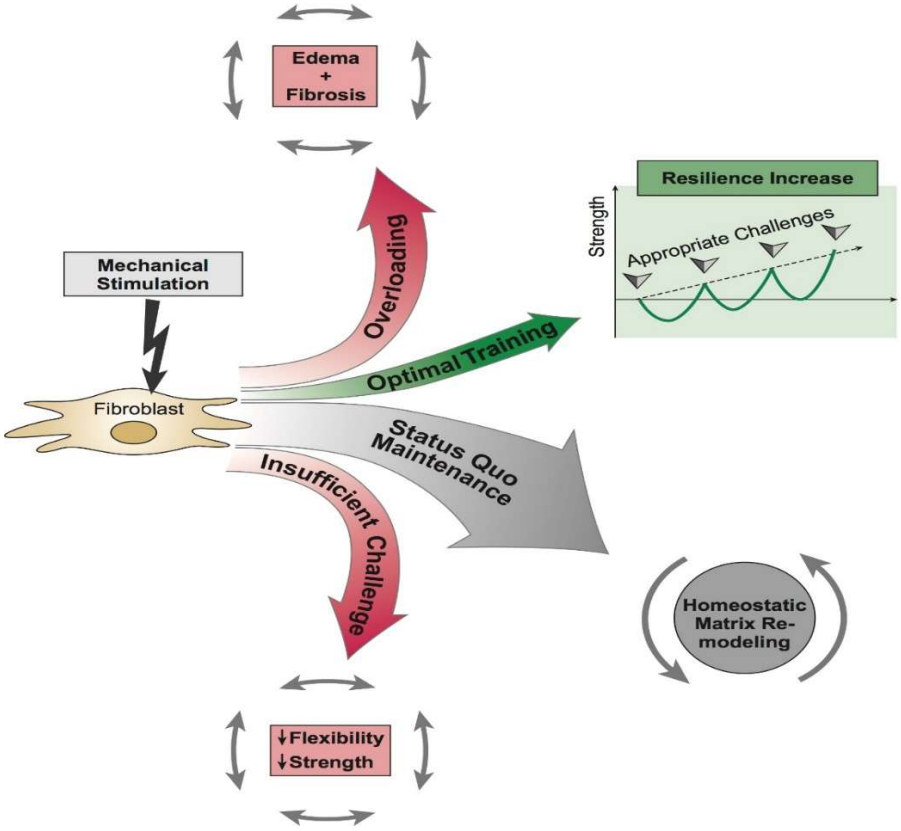


Figure 3.4 Davis Law simplified

Mechanical stimulus on the fibroblast will either have one of the following 4 different effects (overloading, optimal loading, maintenance or underloading) based on the characteristics of the stimulus (Fig 3.4). The stimuli can be characterized based on the external need. In physical rehabilitation and sports training, the SAID principle asserts that the human body adapts specifically to imposed demands. In other words, given stressors on the human system, whether biomechanical or neurological, there will be a Specific Adaptation to Imposed Demands (SAID).

Mechanotherapy/mechanical stimulus can be seen as the vehicle that will carry the stimulus for some form of adaptation.

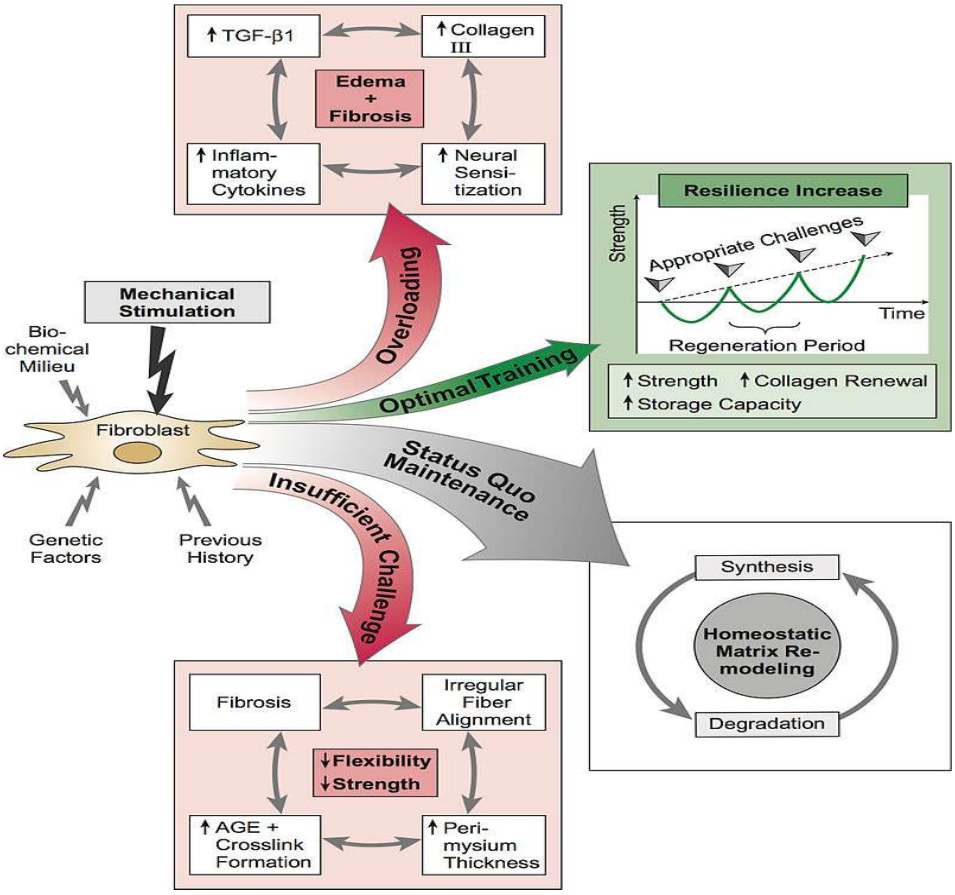


Figure 3.5 Optimal loading within the SAID principal context

Studies demonstrate that complete removal of mechanical load from the healing site is detrimental, but excessive load is also harmful (Fig 3.5). In general, some controlled mechanical loading is necessary for the adaptation of tensile strength within the ligament, tendon and other musculoskeletal structures, while preventing pathophysiological responses within tissues which can be detrimental to the systemic and non-systemic physiological homeostasis (Killian et al., 2012).

Mechanical loading can take many different forms and may involve the manipulation of loading variables to stimulate specific metabolic, neural and morphological changes. The manipulation of training variables in injured athletes can have a profound effect on both the rate and quality of recovery or the incidence of reinjury (Glasgow et al., 2017 and Sugimoto et al., 2016).



Figure 3.6 Overloading

Glasgow *et al.,* (2015) proposed the goldilocks philosophy of “it is just right…” in terms of rehabilitation and the right amount of loading for different structures/systems. This phenomenon is being adapted all over the world in terms of functional rehabilitation principals and the progression thereof leading up to return to activity or sport. If the injured/ill patient is progressed too hastily, there is the risk of exacerbation of the injury or increase risk for the metabolic patient. This could potentially predispose the injured structured to a subsequent injury and lengthening of rehabilitation duration or either increase contra-indications risks for the metabolic patient. Yet, too cautious continuation will also unnecessarily lengthen the rehabilitation duration. Ideally, there would be some clinical mile stones that predicts optimal loading through continuous rehabilitation programme assessments and adjunct adjustments to guide injury/illness risk management (Optimal Loading Congress 2017).

The optimal load or dose of mechanotransduction therapy is case specific. Mechanical loading, based on exercise and movement seems to have a special affinity with the body and may represent the most potent and effective method to present healing to an injured structure.

Optimal physiological loading works through various cellular and neural mechanisms to induce a wide range of changes (summarised in Figure 3.7). Manipulation of loading variables (sets, repetitions, magnitude, frequency, etc.) can have profound effects on the nature, structure and function of the wider neuromusculoskeletal system (Glasgow et al., 2015). The goal of the clinician is to identify and progress to the optimal level of loading or difficulty of a movement that provides significant mechanical and neural stimulus while preventing poor quality, rigid movement or excessive overload (Glasgow et al., 2015).

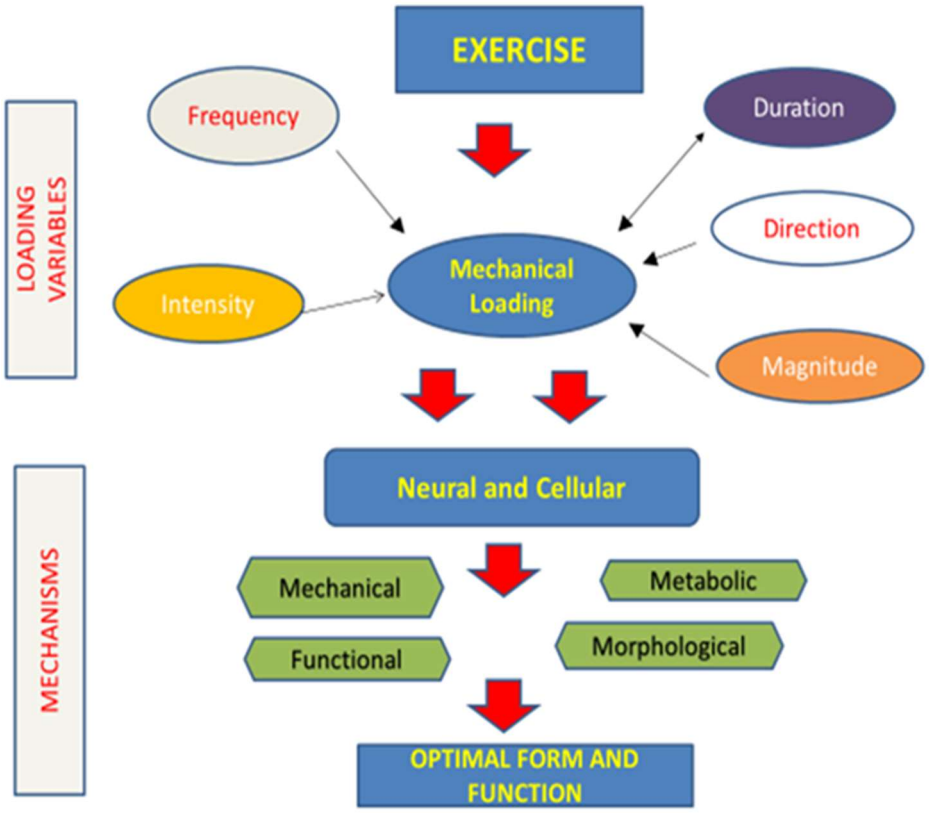


Figure 3.7. Effect of mechanical loading (Glasgow et al., 2015)

It all culminates to the optimal amount of mechanical load applied to certain structures with a certain physiological adaptation ability within a certain clinical timeframe.

In summary, optimal loading for specific adaptation should consider integration of the entire neuromusculoskeletal system. For loading to be optimal, it should be directed to the appropriate tissues and gradually progressed in terms of magnitude, direction and rate (Table 3.1).

3.4 Optimal loading and return to play

Success in rehabilitation means different things to different people and is context-dependent and outcome-dependent. To the athlete, success might be defined by return to sustained participation in sport in the shortest possible time (goal focused). To the coach (and many athletes), success might be defined relative to the athlete's performance on RTS (performance focused). To the clinician, success might be defined by the prevention of new (or recurring) associated injuries (outcome focused). The decision-making team must collaboratively decide on how success will be defined, as soon as possible after the injury/illness.

Optimal Loading	Sub-Optimal Loading
Directed to appropriate tissues	Non-specific generalised loading
Loading through functional ranges	Loading through limited ranges of movement
Appropriate blend of compressive, tensile and shear loading	Loading exclusively in a single manner
Variability in magnitude, direction, duration and intensity	Constant, unidirectional loading
Include neural overload	Minimal neural stimulus
Tailored to individual characteristics	Generic, non-individualised
Functional	Non-functional, isolated segmental loading

Table 3.1 Optimal Loading vs Sub-Optimal Loading (Philips et al., 2015)

Contextual factors influence the expectations and risk tolerance for return to play. These include the type of injury or illness (e.g. acute vs chronic), the athlete's age (or stage of career), type of sport played (e.g. individual or team, contact or non-contact), physical demands of the sport (e.g. cutting, pivoting, landing), level of participation (e.g. amateur professional), significance of upcoming participation opportunities (e.g. championship match, Olympic final, preseason practice) and social and financial costs.

Load progression is a key component of any form of rehabilitation and return to activity decision-making. Achieving and maintaining optimal loading are important clinical considerations. Monitoring the training load during rehabilitation interventions is a crucial component of information when considering someone's progression or regression. This will enable clinicians to make EBM decisions on current interventions while considering all the risk factors that can influence final outcomes.

3.5 Load specific to the demand (SAID)

In physical rehabilitation and sports training, the SAID principle asserts that the human body adapts specifically to imposed demands. In other words, given stressors on the human system, whether biomechanical or neurological, there will be a Specific Adaptation to Imposed Demands (SAID). This principle recognises the specificity of adaptation on macro and micro structural level to a specific training stimulus (Blanchard & Glasgow, 2014). The mechanical responses of joint, ligament and tendon structures are connected to the specific characteristics of delivery of the stimulus which is dependent on the of the input (exercise) signal (Toigo & Boutellier, 2006). Intervention progressions need to be connected to the optimal loading characteristics of the training stimulus to produce the desired final outcome (Glasgow et al., 2015).

3.6 Optimal loading and Shared Decision-Making (SDM)

Using an appropriate combination of research evidence, patient preference and clinical expertise, high-quality, intensive rehabilitation and a highly motivated patient are important for optimal outcomes. Functional and sport-specific conditioning tests play an important role in RTS decision-making and many of the factors deemed.

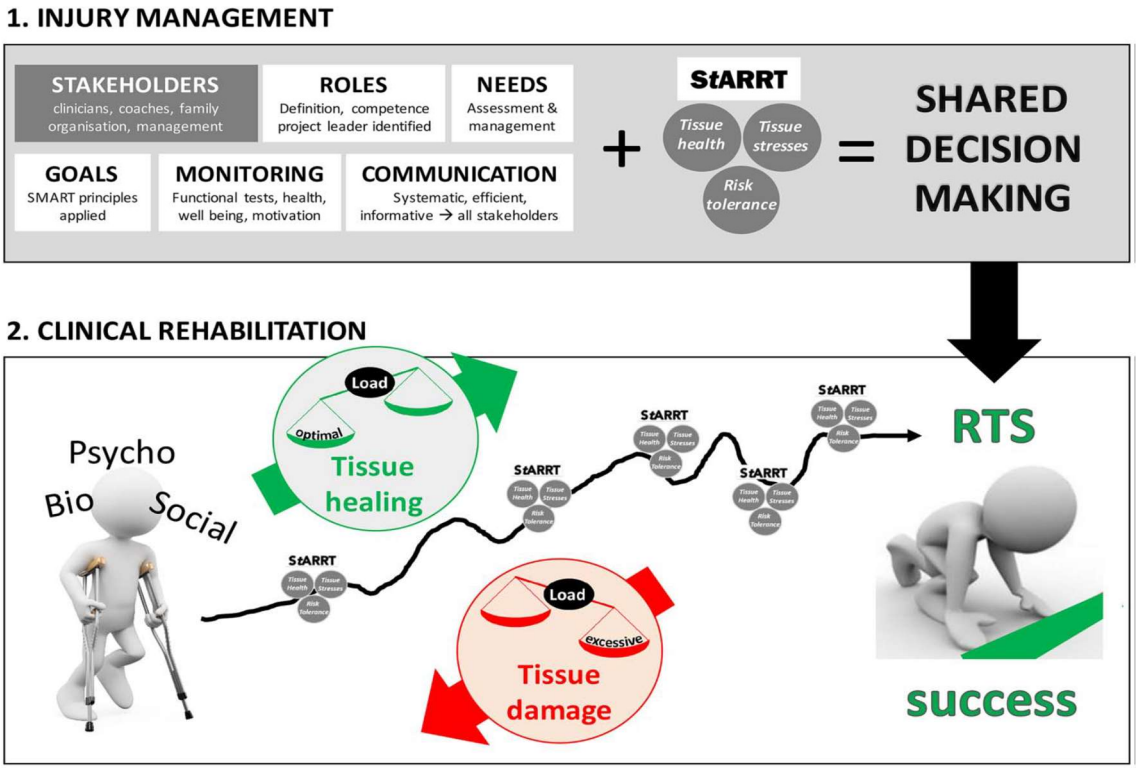


Figure 3.8 Integrating RTS information to make an optimal decision

The top part (1) describes the management aspects that need to be addressed to lead the rehabilitation project. The bottom part (2) shows the progression of rehabilitation on a timeline, where load is progressively increased to promote tissue healing, but can be excessive and require adaptation to avoid damage. These adaptations go through iterations where the StARRT (Chapter 6) model is applied at different time points until eventual full RTS. Final decisions are reached by applying a shared decision-making process (Arden et al., 2015).

Core objectives for the multi-disciplinary team

▸ The composition and roles within the decision-making team should be determined as early as possible.

▸ Members of the RTS decision-making team should be prepared to regularly share information among all relevant stakeholders.

▸ Regular assessments and review of goals should be scheduled.

References

Blanchard, S., & Glasgow, P. (2014). A theoretical model to describe progressions and regressions for exercise rehabilitation. *Physical Therapy in Sport*, *15*(3), 131–135. https://doi.org/10.1016/j.ptsp.2014.05.001

Glasgow, P., Phillips, N., & Bleakley, C. (2015). Optimal loading: Key variables and mechanisms. *British Journal of Sports Medicine*, *49*(5), 278–279. https://doi.org/10.1136/bjsports-2014-094443

Khan, K. M., & Scott, A. (2009). Mechanotherapy: How physical therapists' prescription of exercise promotes tissue repair. *British Journal of Sports Medicine*, *43*(4), 247–252. https://doi.org/10.1136/bjsm.2008.054239

Slade, S. C., Dionne, C. E., Underwood, M., & Buchbinder, R. (2016). Consensus on Exercise Reporting Template (CERT): Explanation and Elaboration Statement. *British Journal of Sports Medicine*, *50*(23), 1428–1437. https://doi.org/10.1136/bjsports-2016-096651

Thompson, W. R., Scott, A., Loghmani, M. T., Ward, S. R., & Warden, S. J. (2015). Understanding Mechanobiology: Physical Therapists as a Force in Mechanotherapy and Musculoskeletal Regenerative Rehabilitation. *Physical Therapy*, *96*(4), 560–569. https://doi.org/10.2522/ptj.20150224

Toigo, M., & Boutellier, U. (2006). New fundamental resistance exercise determinants of molecular and cellular muscle adaptations. *European Journal of Applied Physiology*, *97*(6), 643–663. https://doi.org/10.1007/s00421-006-0238-1

CHAPTER 4

Clinical Reasoning Algorithm

It seems that a text describes one reality—in which the Biokineticist is a passive recipient of knowledge about diseases—while the clinician/private practitioner is required to function in a different reality—one that consists of making sequential decisions. In contrast to the textbook, the clinical algorithm, or flow chart, is a graphic format that sets forth a stepwise procedure for making decisions about the diagnosis and treatment of a clinical problem (See last page of this chapter). The reason for such a clinical algorithm is that we currently follow a reductionistic (over simplifying) approach in our clinical treatment strategy. In order to lay the foundation for a strong industrial Biokinetic development, it is been proposed to follow a more structured plan to eliminate current risk in our clinical decision-making process.

Creating a clinical reasoning algorithm for Biokineticists can therefore assist them in managing their day-to-day patients from assessment to discharging them.

This clinical reasoning algorithm will enable them to utilize their clinical tool (exercise as primary or secondary intervention) in a more practical way. This will also provide us with a more stable platform from where we can integrate EBM in our clinical decision-making processes.

This should enable us to provide patient outcome measures at the right time and to improve clinical decisions on the success/failure of the applied exercise intervention. The only reason for creating an algorithm is to help Biokineticists better understand their current information within a dynamic workflow which will enable them to add value to their patients and to the interprofessional team.

Practical application of Clinical Reasoning Algorithm

All exercise rehabilitation, within the scope of Biokinetics, starts within the 10 Fields of Rehabilitation. During preliminary studies a Biokineticist is exposed to these clinical conditions and through education students should be able to treat these conditions (injury/disease/illness) with exercise either as primary or secondary intervention.

Define the injury/illness in layman's terms

The clinician should have the ability to understand the most basic foundation definition of any injury or illness to effectively follow the clinical reasoning algorithm. **For example:** Patellofemoral pain can be defined as the injury that occur when the contact area between the posterior lateral aspect of the patella and the lateral femoral condyle increases**.**

Aetiology

These injuries/illness/diseases could have been set off by a cascade of factors which can be summarized in the aetiology of the pathological condition. This normally develops out of the multifactor nature which could be concluded in the biopsychosocial model of risk factors, which could lead to the

commencement of a certain condition. **For Example:** Patellofemoral pain can be caused by multiple risk factors located in the Biopsychosocial Model. These factors could be intrinsic systemic (non-modifiable) like structural changes (Patellofemoral joint chondromalacia patella) or age. Intrinsic non systemic (modifiable aspects), like increased knee valgus (abnormal biomechanics) could influence the final outcome. Extrinsic factors, like running shoes or environmental factors could have an effect on the prognosis of Patellofemoral pain outcomes. Lastly, training factors like too much too soon (FITT-VP) and poor running form needs to be addressed to improve overall outcomes (Figure 4.1).

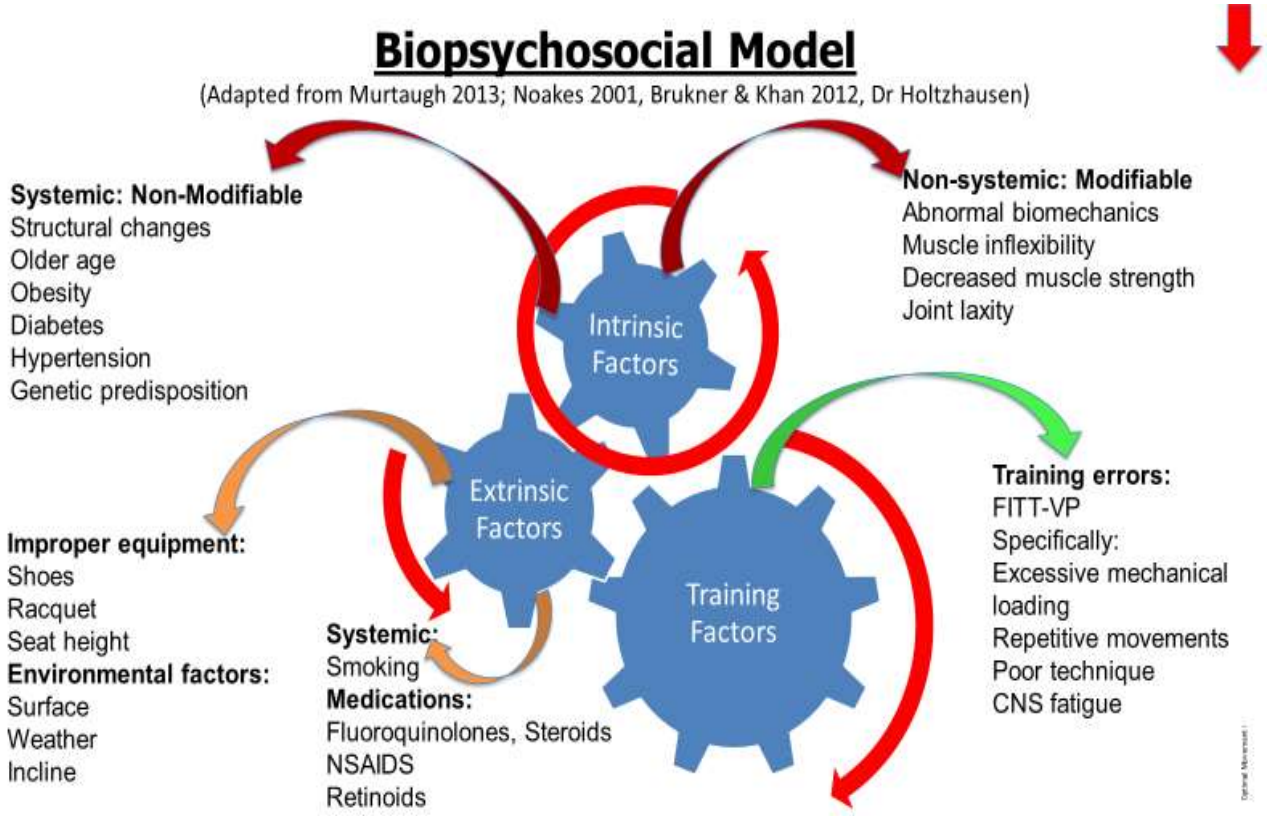


Figure 4.1 The Biopsychosocial Model

Pathophysiology

After a certain condition has started and it develops into a certain disease, illness or injury a Pathophysiological Model develops based on the consequences of the state of the systemic and non-systemic systems. This normally can create a kaleidoscope effect on the current picture in front of you, in terms of, what drives the initial problem to a combination of biopsychosocial risk factors combined with some of the effects of the Pathophysiological Model. In summary, the pathophysiological definition could be seen as the functional/morphological/mechanical/systemic changes caused by the disease/illness/injury. **For Example:** Posterior Gluteus Medius weakness could have developed out of Patellofemoral pain and could actually have an effect on the ability of the lumbo-pelvic hip complex to handle external loading and controlling the femoral position, especially during midstance phase during the running cycle.

Pathoaetiology: Altered running biomechanics could be the effect of Patellofemoral pain, this could influence the optimal recruitment of the posterior-lateral structures of the hip.

Summary:

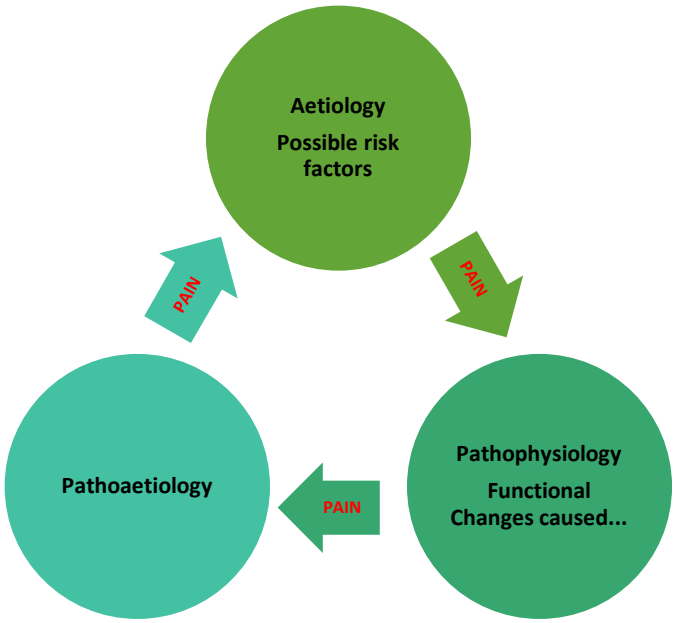


Figure 4.2 The inter-relationship of Aetiology and Pathophysiology

Assessment: Diagnostic/PROM and PBOM Outcomes

When Biokineticists need to evaluate a certain patient he/she needs to understand what are they evaluating. First and foremost, the evaluation will be a combination of the aetiology, pathophysiology and pain or discomfort as an entity of that specific problem (Figure 4.2). Secondly, we evaluate the systemic and non-systemic (neuromuscular, neural, skeletal) effects of the moments of pain/discomfort on a system (patient) occurring over time.

Lastly, we need to see the first assessment as a continuum with diagnosis on the one end and Patient reported outcomes(PROM) measure, Performance based (PBOM) Clinical outcomes (CO) indicators on the other end (Figure 4.3) . If the patient walks through door with a referral letter from a medical professional, the assessment will be directed to the set-up of PROM, PBOM and CO and secondary outcomes (Systemic/Non-Systemic outcomes) indicators which will give feedback on the intervention success (Green as seen in Figure 4.3). Students should have the knowledge of what the PROM and PBOM are and which one of them have the highest sensitivity to change the overall outcome.

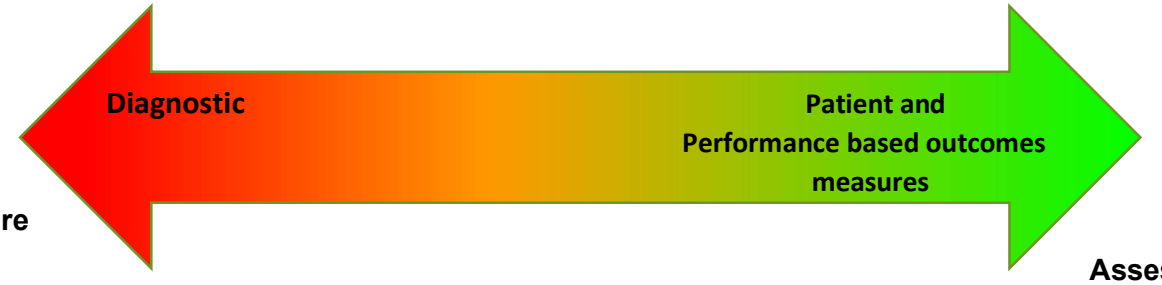


Figure 4.3 Assessment continuum

If the patient presents himself without a differential diagnosis, the Biokineticist needs to use his diagnostic skill set within his/her scope of practice for the preparation of a referral letter to a medical doctor for further investigation of the pathology (Red as seen in Figure 4.3). The diagnostic testing should include information from the aetiology/pathophysiology and pain. The student should know the possible cluster of tests that could be done to evaluate possible diagnosis for further referral purposes.

Criterion-Based Rehabilitation Progression (CRP) model vs Time-Based Rehabilitation Progression (TRP) model

A criteria-based rehabilitation protocol requires that a set criteria (specific physical testing) is achieved prior to allowing progression to the next stage (Figure 4.4). The move towards a criteria-based progression protocol is crucial for successful rehabilitation and will allow the clinician to better integrate objective measures as well as subjective measures into the clinical reasoning process (Van Dyk et al., 2019). The CRP model highlights the need to apply clinical knowledge in a system thinking order to achieve a certain objective within a certain time frame which connects with the healing responses of that particular system. Based on the FITT-VP principal, recommended by the ACSM guidelines, we proposed a more structured infrastructure been used during day-day rehabilitation sessions where clinical status measurements guides daily clinical decision-making. The reason for proposing a CRP model, is to highlight the individuality of the rehabilitation process concerning certain goals that need to be met by the patient. The progression of the rehabilitation will be built on the retrospective success of the previous phase.

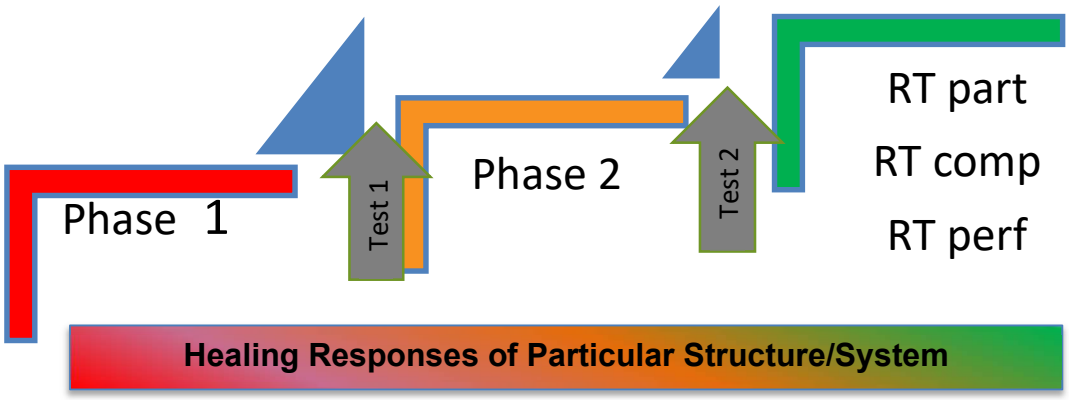


Figure 4.4 Criterion-Based Rehabilitation Progression model

The above mentioned, will give guidance to the Biokineticist in practice of the success/failure rate of the implemented rehabilitation programme on a weekly/monthly basis. It is important for Biokineticists to understand when to use what model (CPR and/or TRP) or complementing two models in a certain pathophysiological condition.

Time-based Rehabilitation Progression (TRP)

This model of rehabilitation progression is solely determined by the specific healing responses of the specific pathophysiological condition (illness/disease/ injury).

Rehabilitation Workflow (ABC)

The rehabilitation workflow designates a management system for biokinetic healthcare strengthening. This is an infrastructure which will create a platform for clinical reasoning were all the decision-making on daily/monthly bases can take place. This structure contains all the important elements of a scientific program prescription and reporting components according to the CERT statement (Published in the British Journal of Sport Medicine). This infrastructure is design to optimize rehabilitation outcomes but also be time efficient. Step A focuses only on initial assessment which will move on to initial reporting in Step B. Thereafter, the proper development of the exercise intervention in Step C. This process will be iterative in the follow up/progress assessment, starting in Step A again after completion of Step C. A full discussion will be presented in chapter 5 on the working elements (A-B-C) in the workflow.

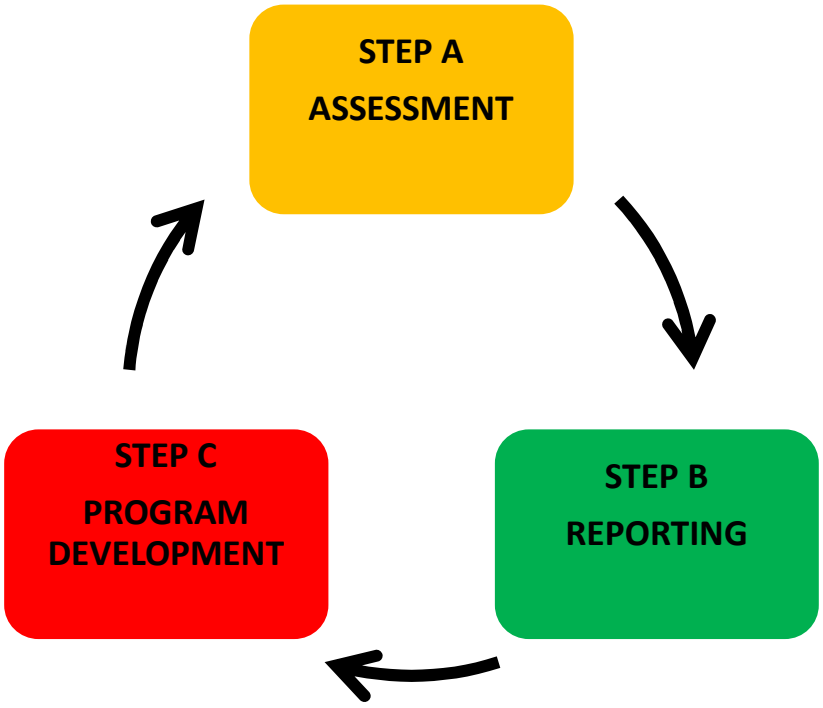
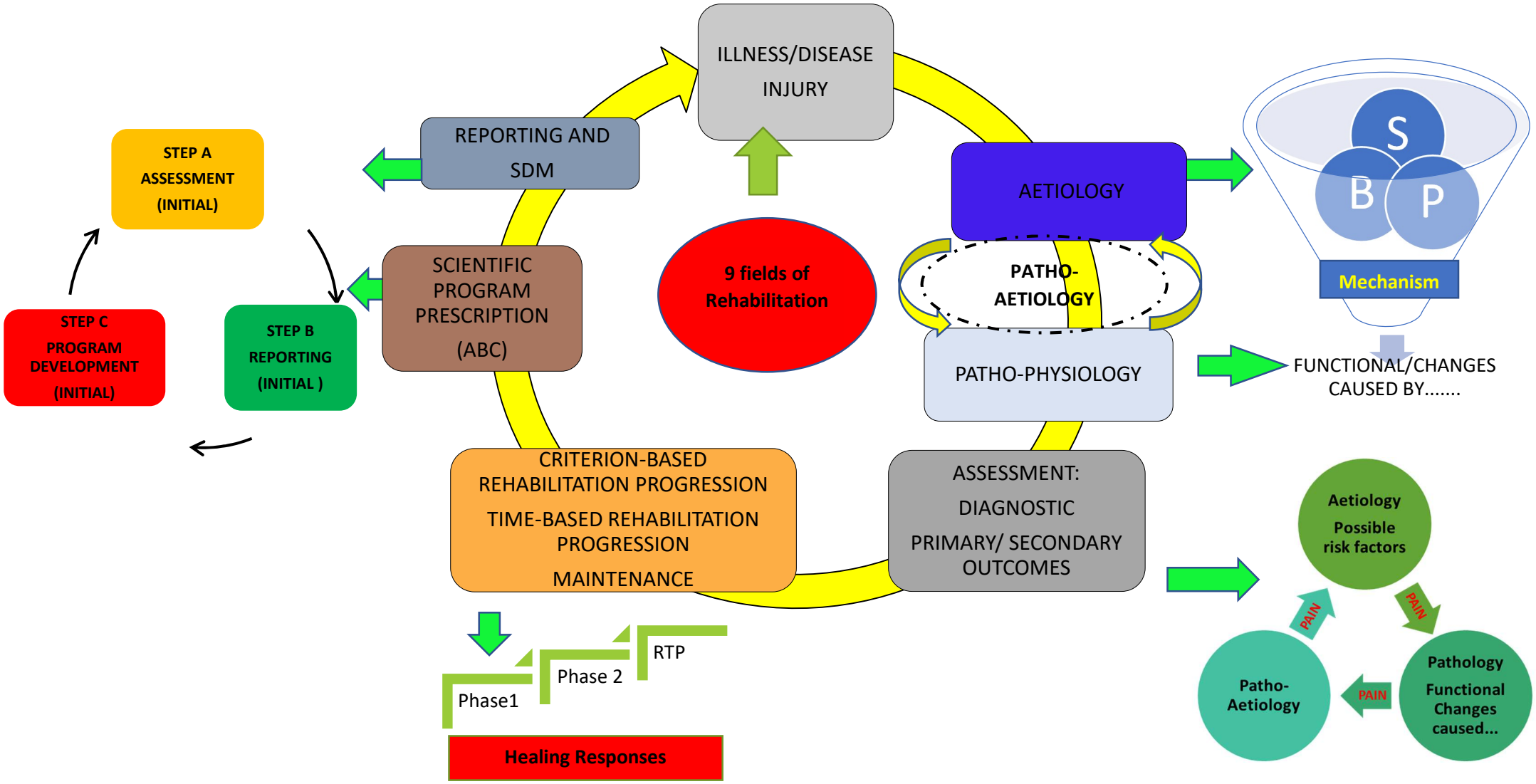


Figure 4.5 Injury/Illness risk management algorithm

Reporting and Share Decision-Making

Decision-making in the inter-professional team could be challenging because of the diversity within the different occupations which could lead to a difference in focus on what is important information for whom and for what. A common denominator should be established between the inter-professional groups that can be used in the return to activity/competition/performance decision-making of the patient/athlete, or guidance on a different clinical intervention if exercise is not the ideal intervention.

Clinical Reasoning Algorithm (Vlok. 2019)



CHAPTER 5

Injury/Illness Risk Management

If you fail to plan, you plan to fail…

Outcomes of Module

1. **Assessment (Initial/Progress)**
2. **Reporting (Initial/Progress)**
3. **Program development (Initial/Progress)**

The discussion will follow the Management Cycle (Figure 5.1)

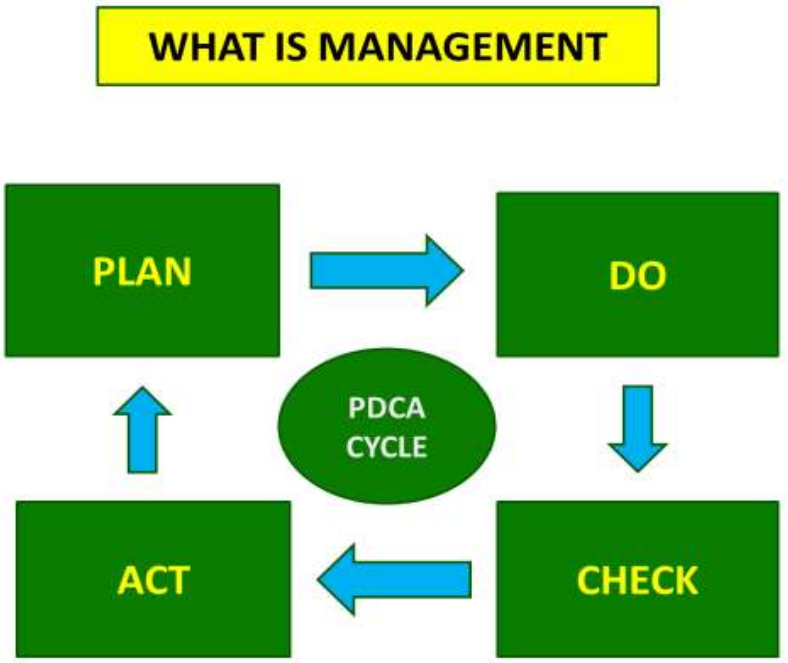
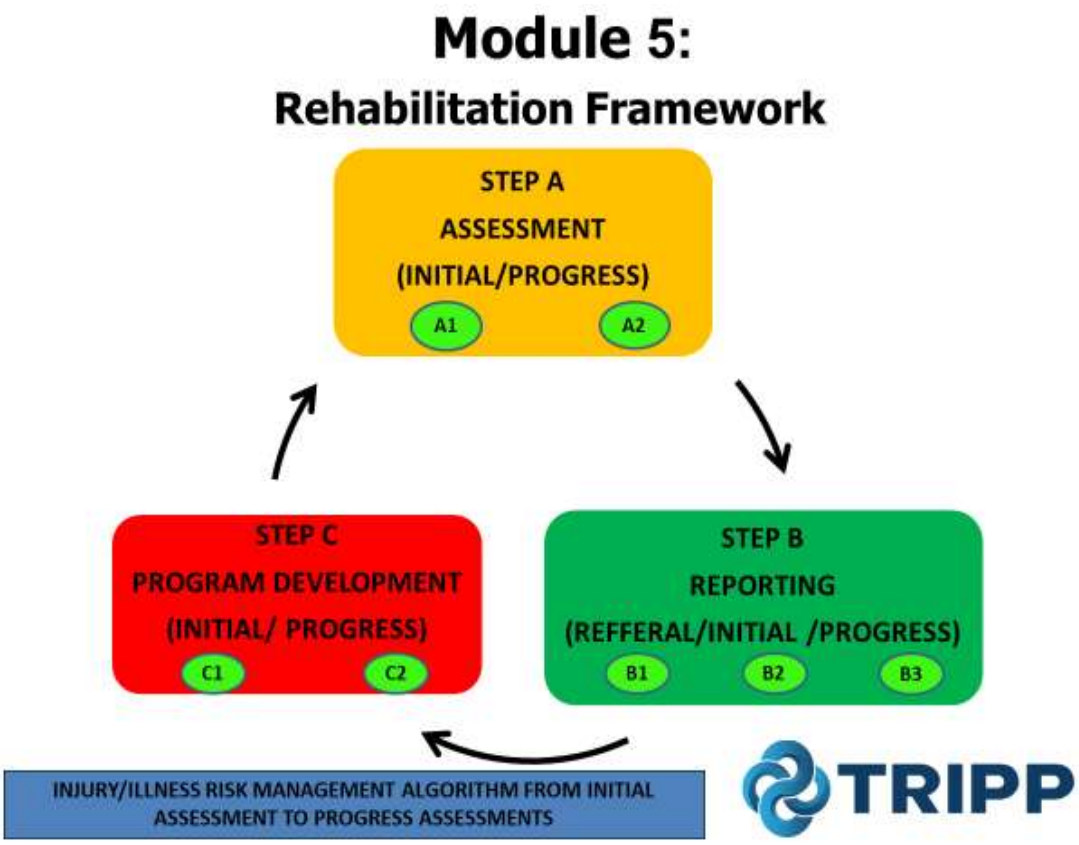


Figure 5.1: Management cycle

5.1 What is management

Management is an art of knowing what to do, why to do it and the how to do it in the best possible way. The integrating part of management is the plan to what, why and how to do something. Thereafter, execute the task, check if it was according to the desired outcome and act on the information before you plan again (Figure 5.1)

Any rehabilitation process can only be successful when the following sequential steps are followed. The following section will provide an outline of the proposed rehabilitation process which will be covered completely in Chapter 5. This section will introduce the student with an outline of the process as entity by covering the main theoretical definitions and the chronological workflow within the injury/illness risk management process.



.

Figure 5.2 Injury/Illness risk Management (Step A)

5.1.1 Step A: Assessment (Initial/Progress)

The following components will be an outline of the beginning of the rehabilitation process.

A.1 Create a patient profile:

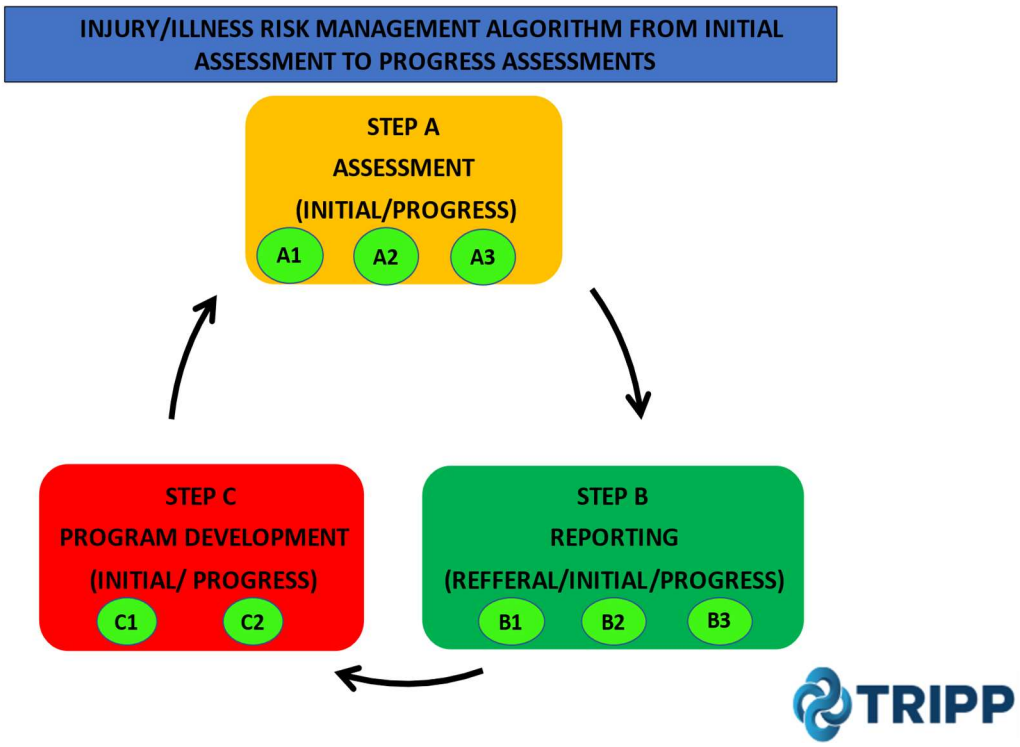
These could be seen as important patient descriptors which will influence the rehabilitation administrative process (Age, Gender, Primary Diagnosis, etc.)

A.2 Install estimated timelines for duration of rehabilitation process:

Macro, Meso, Micro cycles - Definitions to follow

A.3 Set up the Patient Reported Outcomes Measures (PROM's) and Performance-Based Outcomes Measures (PBOM) functional milestones/clinical indicators for the first mesocycle:

It has been suggested that a key feature of injury/illness/disease rehabilitation is the identification of functional milestones to be achieved, and documenting progress using continuous evaluation, of the PBOM's and PBOM's which is necessary to guarantee a confident and timely return to training and competition or active lifestyle.



Definitions:

Macrocycle**:** The macrocycle is the overarching cycle that is indicative of the completed projected timeframe of the rehabilitation period. (Projected "months" of rehabilitation process)

Mesocycle**:** This cycle refers to the individual phases/stages of rehabilitation. (4-6 weeks before first, second or third re-evaluation takes place)

Microcycle**:** This refers to the individual training sessions which will be in one mesocycle. (Sessions per week)

Patient reported outcomes measures (PROM's): PROM's has been defined as "any report" of the status of a patient's health condition that comes directly from the patient, without interpretation of the patient's response by a clinician or anyone else.

This group of outcomes can consist of:

1. Subjective scoring sheets for all the 10 fields of rehabilitation in Biokinetics.
2. Pain measured according to the visual analogue scale (VAS) during rest or movement.
3. Rate of Perceived Exertion (RPE) measured during the desired activity for a specific condition. This group of subjective measured outcomes as an investigator, considers to be the most important among the many outcomes that are to be examined in the intervention.

Performance Based Outcomes Measure (PBOM): Performance-based measures require the patient to perform a set of movements or tasks. Scores for performance-based measures can be based on either an objective measurement (e.g. time to complete a task) or a qualitative assessment that is assigned a score (e.g. normal or abnormal mechanics for a given task).

Daily Clinical Status Indicators: Session measurement of clnical status (blood pressure, sugar, pain ect.) markers of patient to inform the Biokineticist of any changes in systemic or non-systemic homestasis that coud influence exercise programme on that particular training day.

Figure 5.3 Injury/Illness risk Management (Step B)

5.1.2 Step B: Reporting on the PROM's, PBOM's and Clinical outcomes (Initial/ Progress):

Action step. Take the Progress assessments PROM's, PBOM's and Clinical outcomes and deduct it from the initial assessment PROM's, PBOM's and Clinical outcomes after the Biokineticist completed the dedicated amount of intervention sessions.

Success of the intervention can be expressed in different ways, like Minimal Clinical Important Difference (MCID), Leg symmetry index (LSI), Benchmark (BM) and progression. The following definitions can provide the basis from which robust clinical reasoning can be derived.

Definitions:

Leg symmetry index (LSI): This is a standardized reporting method to identify possible asymmetrical changes by comparing the involve with the uninvolved side.

Formula used:(Mean Involved/Mean Uninvolved) *100/1

Benchmark (BM): A standard or point of reference against which things may be compared.

Formula used: (Test Results/Benchmark) *100/1

Progression/Regression Measurements: This is when follow-up testing is compared to initial testing results to identify the positive/negative progression curve.

Formula used: (Follow-up testing results - Initial testing results) *100/1

Minimal Clinical Important Difference (MCID): Some of the reporting will be done based on the principal of measuring the minimal clinical important difference (MCID). When assessing the clinical utility of therapies intended to improve subjective outcomes, the amount of improvement that is important to patients must be determined. The MCID is a patient-centred concept, capturing both the magnitude of the improvement and also the value patients place on the change. The MCID defines the smallest amount an outcome must change to be meaningful to patients.

Where to go with the info?

This information should be communicated, in the simplest way, to all the stakeholders to understand and provoke the following action steps in the management cycle.

B1: Internal Information can be drawn on the success/failure of current intervention. This should indicate a change of program intensity in the next mesocycle.

Internal performance indicators: Minimal Clinical Important Difference (MCID) of the different outcome measures should direct further rehabilitation intervention layout.

B2: External Relevant information can be discussed among the different stakeholders (medical team, coaches, parents, insurance brokers, medial aids) to make pre-operative and post-operative management decisions concerning patient care.

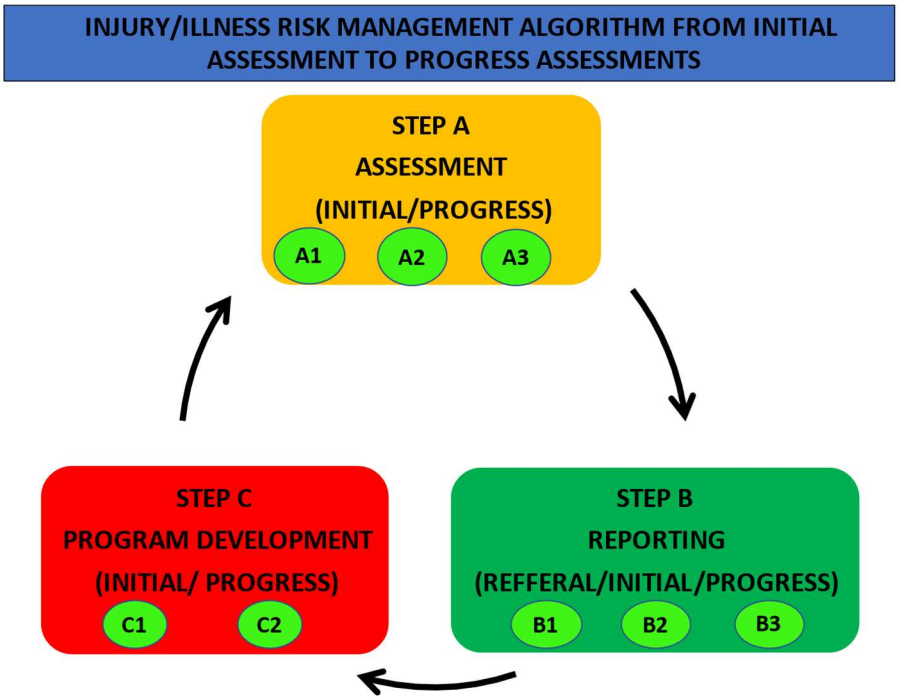


Figure 5.3 Injury/Illness risk Management (Step C)

5.1.3 Step C: Programme Development (Initial/ Progress):

C 1: Set up the clinical status indicators. This action step needs to be compulsory according to HPCSA practice regulations. Each injury/illness will have its own indicators.

C 2: Set up program content for specific condition according to EBM guidelines.

In step C2 of program development, the Biokineticist should make an informed decision on the right selection of the different exercise components (Y_1-Y_7) which are applicable to the patient's condition. Thereafter, the correct exercise selection and the manipulation of the content (X_1-X_{13}) within each component needs to be pinned down.

This method of rehabilitation, to improve the PROM's and PBOM's, can be defined as the planned manipulation of specific training variables/content (load, sets, and repetitions) in order to maximize training adaptations, without jeopardizing the internal homeostasis on systemic and non-systemic physiological level.

Definitions:

Program Format (Y_1-Y_7): Information about the specific program components like cardiovascular, strength, flexibility, mobility, neuromuscular control training, plyometric training and agility.

Program Content (X_1-X_{13}): Information about repetitions, sets, load magnitude, time under tension, tempo, anatomical position, fractural temporal distribution of the contraction, exercise interventions, range of motion, recovery time between sessions and voluntary muscular failure.

Program Outcomes:(Z_1-Z_2): PROM's and PBOM's.

Contact sessions with Biokineticist and first re-evaluation

Session 1-8 (Figure 5.4) can be observed as the execution of the particular intervention which any Biokineticist can follow on each contact session. This summary figure concludes with the first re-evaluation after completion of the suggested number of sessions, thereafter, the ABC process will follow again by starting with Step A progress assessment (Figure 5.4). All the diagrams showed with dash lines indicating the re-evaluation process which is a duplicate of initial ABC process.

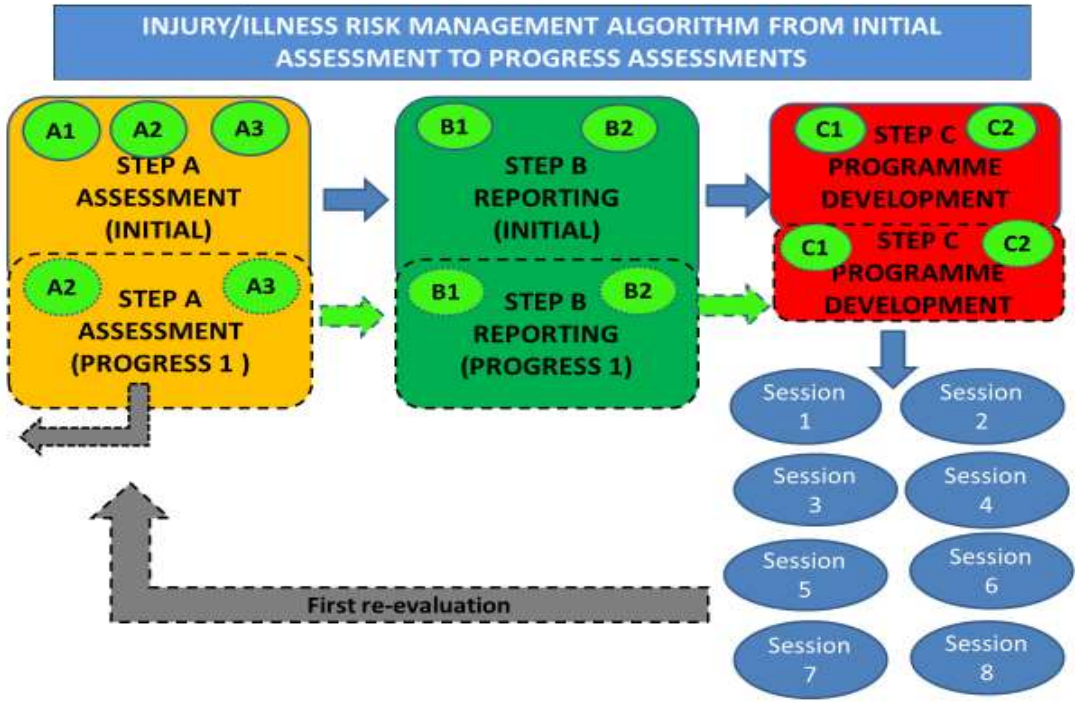


Figure 5.4 Injury/Illness risk Management (Summary of process)

Chapter 6

Consistency is the ultimate currency

Outcomes:

1. **Why progressive overloading**
2. **What is progressive overloading**
3. **Measurement of progressive overloading**
4. **How to do progressive overloading of the different exercise components within a rehabilitation program**

6.1 Why progressive overloading

Progressive overload (PO) could be defined as the manipulation of the FITT-VP variables in a rehabilitation programme to gradually increase the stress placed upon the body during exercise training. The effect of progressive overloading can be summarized in the increase in fitness and strength levels of the body (Figure 6.1). The understanding and the critical application of progressive overloading in the 10 fields of rehabilitation is of utmost importance for any Biokineticist working in the field, where exercise is being used as a primary or secondary intervention for medical pathological conditions. This principal should be highlighted in the curriculum for Biokinetics to help students and so futuristic clinicians to develop their understand of the PO principal and their responsibility to manage it on a daily basis.



Figure 6.1 Progressive overloading diagram

The science of progressive overloading is quite complex and cannot be included in the current principal being used in Biokinetic practice of increasing the load from 3*10 repetitions to 3*15 repetitions. The power of progressive overloading should be conceptualized in the SAID (Specific Adaptations to Imposed Demands) principal, which states that the body will adapt to the specific demands placed upon it through the rehabilitation period. In summary, PO is the ability to manage a rehabilitation programme in such a way that the maximum adaption responses will flow from it, while maintaining the internal homeostasis of that particular system or systems. When applying the PO principal with special considerations within the biopsychosocial model, it could improve the outcomes measure vividly in most of the illness/disease or injury driven conditions.

6.2 What is progressive overloading and the value thereof

The essence of progressive overloading (PO) is an art in itself and could only be accomplished by someone who has the knowledge and deep understanding of the impact of the chosen stimuli on the micro and macro systemic and non-systematic environments. The value of PO lies in the ability of the clinician (Biokineticist) to challenge the body or injured structure within its physiological or pathophysiological state to adapt to a certain stimulus. Depending on the clinical status of the patient, and the primary objective/aim of the stimuli, this should improve the ability of patient/athlete to handle more physiological demanding external loading which in return will increase fitness and so health of that particular patient/client. Progressive overloading could be induced through the neuromuscular training modalities like strength, neuromuscular control training or cardiovascular training modalities etc.

Continuous PO could only be accomplished in the presence of homeostasis (internal balance). This should be strictly monitored by the clinician through the clinical status indicators of that particular injury/disease/illness of the athlete/patient on a daily basis. This micro assessment will enable the clinician with some information on the window of opportunity to change stimulus either up (increase program intensity) or down (decrease program intensity) based on the status for that specific day.

6.3 Measurement of progressive overloading

The effect of PO could be measured on various neuromuscular platforms like balance, strength training, cardio-vascular training responses etc. The importance of installing specific secondary outcome measures that should evaluate PO is of utmost importance. The effect of PO could be measured through **musculoskeletal components** that was affected **by the** specific disease/illness/condition. The effect of exercise as an intervention should be reflected

in the improvement of the PROM, PBOM, or CO measures and this should indirectly measure the progressive overloading responses on these different levels.

6.4 Application of progressive overloading (Theoretical model for programme progression (day - day).

Clear clinical reasoning relating to appropriate progression and regression of rehabilitation is essential to achieve positive clinical outcomes. A theoretical model to assist practitioners in this respect has been developed by Blanchard and Glasgow et al., (2015). This model (Figure 6.2) provides a visual means for clinicians to represent modification of rehabilitation stimuli with regard to progression of a single exercise.

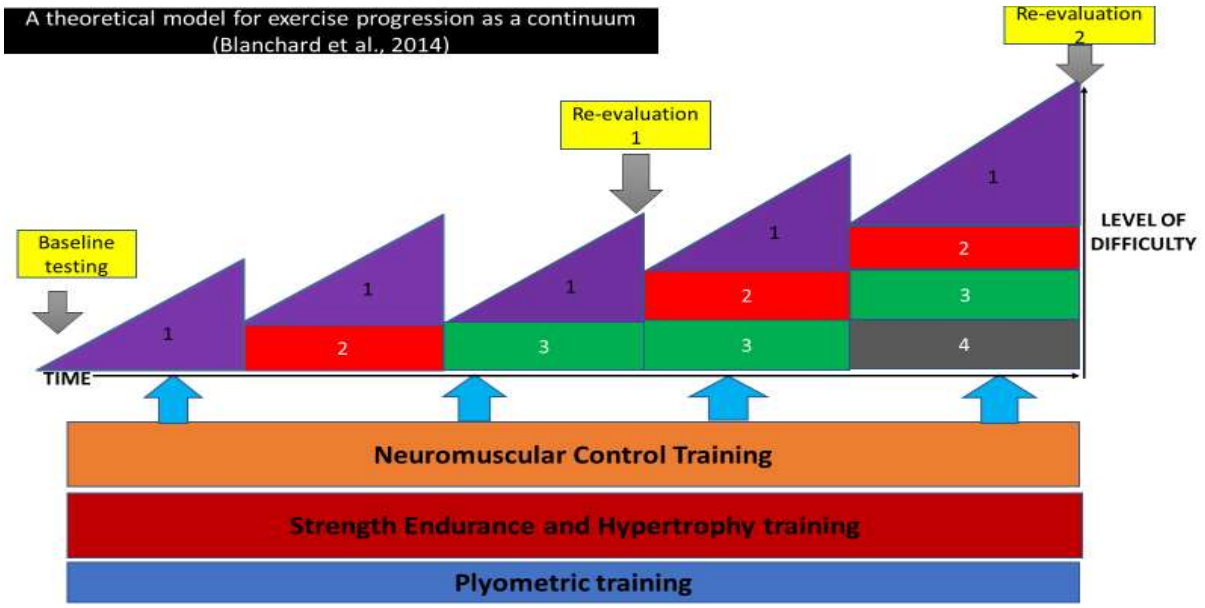


Figure 6.2 Theoretical model for progressive overloading

In order to facilitate such a complex exercise model, Blanchard and Glasgow (2014), developed a theoretical model to describe progressions and regressions for exercise rehabilitation (Fig 6.2). The horizontal axis represents time and the vertical axis the level of difficulty of the exercise. The starting exercise (1) may be progressed by manipulating a number of variables, including (although not exclusively): duration, speed, distance, repetitions; the exact number of variables is dependent on the specific exercise and the goals of rehabilitation. The next stage of progression may be to add an extrinsic component to the exercise (2), such as a change in stimulus by increasing the load or the environment in which the exercise is performed.

6.4.1 Progression of neuromuscular training modalities

Progression in resistance training is a dynamic process that requires a scientific exercise prescription process, evaluation of training progress and careful development of target goals.

The process starts with the determination of individual needs and rehabilitation goals in the format of performance-based outcomes measures (PBOM). This involves decisions regarding questions as to what would be the demand on the injury site, or what functional/morphological/systemic changes could be possibly reversed by the exercise intervention which will be reflected in the target training goals, etc. The single workout must then be designed reflecting these targeted program goals including the choice of exercises, order of exercises, amount of rest used between sets and exercises, number of repetitions and sets used for each exercise, and the intensity of each exercise. For progression, these variables must then be varied over time and the exercise prescription altered to maintain or advance specific training goals, and to avoid overtraining. A careful system of goal targeting, exercise testing, proper exercise technique, supervision, and optimal exercise prescription all contribute to the successful implementation of a resistance training program during pathological conditions.

6.4.2 Three general principles of progression in resistance/strength training are: 1) progressive overload, 2) variation, and 3) specificity.

Progressive overload: This describes the gradual increase of stress placed upon the body during exercise training. It could be done by the manipulation of the X_1-X_{13} exercise descript.tors

Specificity: There is a relatively high degree of task specificity involved in human movement and adaptation that encompasses both movement patterns as well as force-velocity characteristics section. Rehabilitation exercise should be specific to the demand.

Variation: Training variation requires that alterations in one or more program variables to be made over time to allow for the training stimulus to remain optimal.

The act of resistance training, itself, does not ensure optimal gains in muscle strength and performance. Rather, it is the magnitude of the individual effort and systematic structuring of the training stimulus that ultimately determines the outcomes associated with resistance training. Thus, resistance-training programs need to be individualized (e.g. based on individual goals) in order to maximize the outcomes. Ultimately, the goal of a resistance training program is to improve some component of fitness or health until a certain level has been attained. For improvements to occur, the program used must be systematically altered so that the human body is “forced” to adapt to the changing stimuli. Thus, progression may be defined as “the act of moving forward or advancing toward a specific goal, while considering the risk factors for possible overloading’’.

6.4.3 Progressions for specific neuromuscular control effect

The general progression for activities to develop dynamic reactive neuromuscular control is from slow-speed to fast-speed activities, from low-force to high-force activities, and from controlled to uncontrolled activities, from simple to complex movements, from stable to unstable surfaces. This could be seen as the general principles for progression of the neuromuscular control component within the rehabilitation programme. Careful selection of exercises should form the basis of any neuromuscular control training programme. This selection should be based on science and not on increasing complexity of execution while missing the mark on the original aim of the exercise. The general pitfall in the industry in this division of the rehabilitation is either selection of exercise modalities that are too complex and not connected to the final task or for what the exercise was initially selected for.

The NMC progression guidelines could be followed as layout in Table 6.1

The Element, Rehabilitation Techniques, and Afferent/Efferent Characteristics Necessary for Restoring Proprioception and Neuromuscular Control		
Elements	**Rehabilitation techniques**	**Afferent/efferent characteristics**
Proprioception and kinaesthesia	Joint repositioning Functional range of motion Axial loading Closed kinetic chain exercises	Peripheral receptor sensitivity Facilitate afferent pathways
Dynamic stability	Closed kinetic chain exercises and translatory forces High repetition/low resistance Eccentric loading Stretch shortening exercises Balance training	Agonist/antagonist coactivation Muscle activation rate and amplitude Peripheral receptor sensitivity Muscle stiffness
Reactive neuromuscular control	Reaction to joint perturbation Stretch- shortening, plyometrics Balance reacquisition	Reflex facilitation Muscle activation rate and amplitude

Functional motor patterns	Biofeedback Sport-specific drills, Control-progressive participation	Discriminatory muscle activation Arthrokinematics Coordinated locomotion

Table 6.1 External Load Progression

1. Cardiovascular intensity increase

2. Neuromuscular Control intensity progression will be measured in the total time under tension (Repetitions*Sets*Seconds)

3. Strength training progression will be measured in total volume (Repetitions*Sets*Intensity)

4. Plyometric training progression will be a product of Repetitions*Sets=Amount of foot contacts per session.

Internal Load Progression

This will be documented as a product of RPE*Time per session

Neuromuscular Control Guidelines for rehabilitation purposes.

CHAPTER 7

Start with the end in mind

Outcomes of this module

1. **Physiological healing thermostat**
2. **Deep understanding of all the definitions of the different components of a scientific rehabilitation program**
3. **Program content and its different definitions**
4. **Different manipulation strategies with content**
5. **Optimal loading and TRIPP outcomes measurements**
6. **Interpretation of the statistical terminology definitions**

7.1 Physiological healing thermostat

Three theories together give the make up for the physiological healing thermostat

7.1.1 Envelope of function by Dye et al., 1996

7.1.2 Mechanotransduction by Khan et al., 2009

7.1.3 Physical Stress Theory by Hanse Seyle et al., 1960

7.1.1 Envelope of function

This concept focuses on the functional capacity of a structure or system. It assumes that a safe range of loading exists for a certain frequency within a systemic and non-systemic system and this safe or physiologic zone has been termed the “envelope of function” (Figure 7.1).

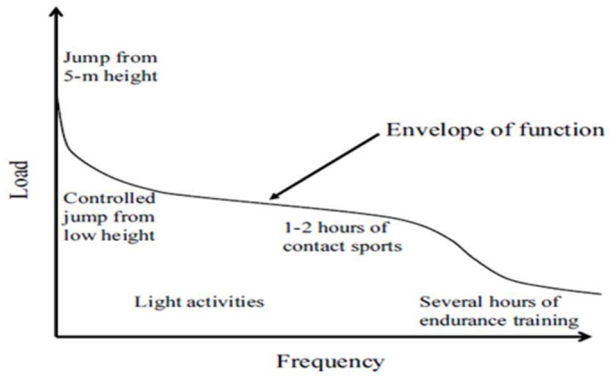


Figure 7.1 Envelope of function.

The area within the envelope is the zone of homeostasis and loads within this range do not cause structural damage or induce pathophysiological responses within tissues. Beyond the

envelope of function (Figure 7.2) lies the zone of supra-physiologic loads (Dye et al., 1999). Loads applied in this zone causes pathophysiological responses like pain, swelling and temperature changes or can open the risk for deleterious effects on systemic metabolisms. Zone above the zone of supra-physiological overload is the zone of structural failure. The zone of sub-physiological underloading is descriptive of a situation where there is minimal physiological adaptation because the load and frequency are very low.

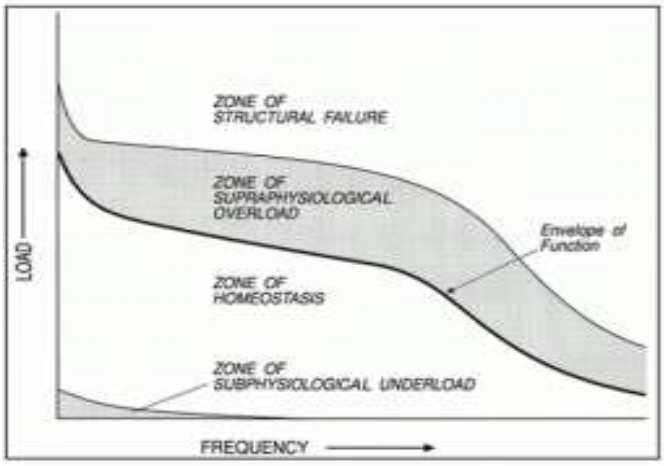


Figure:7.2 Envelope of function and different zones (Dye et al.,1996)

A fine line exists between loading and overloading while homeostasis needs to be maintained within the envelope of physiological function both on systemic and non-systemic levels.

7.1.2 Mechanotransduction/Mechanotherapy

We've covered mechanotherapy extensively in chapter 3. This short section is only to highlight the importance of exercise therapy within a load/frequency relationship. This casual connection can bring the patient to the point of homeostasis and it can be defined as the point where optimal loading can take place. Consistent load being applied over time while considering the envelope of function will generate a physiological adaptational response. The ultimate effect of this physiological response can be tested through the primary and secondary outcomes measurements to evaluate if overloading, optimal loading or underloading have taken place.

7.1.3 Physical Stress Theory

The basic premise of the Physical Stress Theory (PST) is that changes in the relative level of physical stress cause a predictable adaptive response in all biological tissue**.**

The law of functional adaptation introduces the Physical Stress Theory proposed by Mueller in 2002 (Mueller & Maluf, 2002). The theory postulates that there are five tissue responses to physical stress namely a decrease in stress tolerance (e.g. atrophy), maintenance, increased stress tolerance (e.g. hypertrophy), injury and death.

Different definitions of all the components of a rehabilitation program.

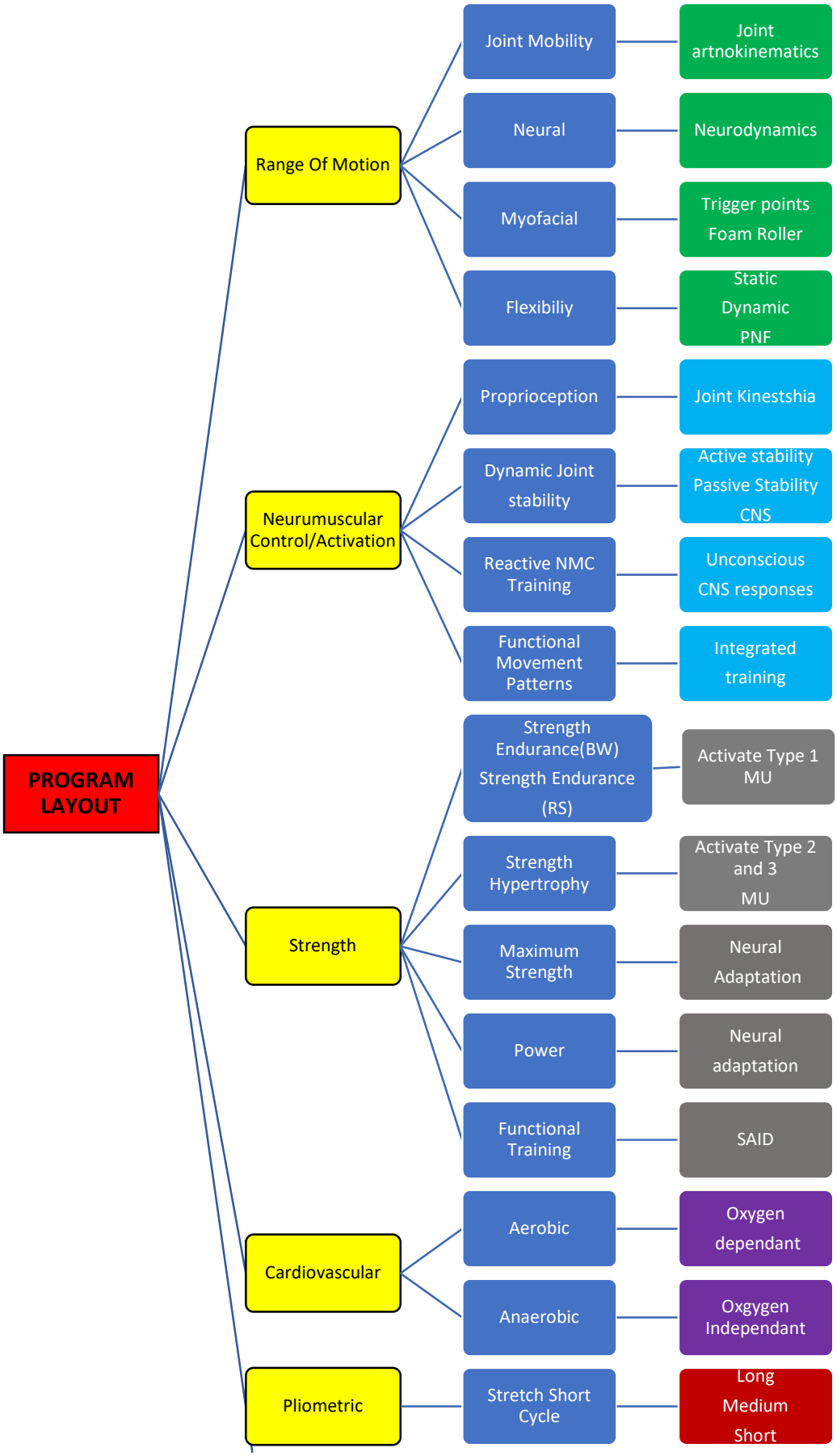


Figure 7.3 Program layout for rehabilitation purposes

7.2 Program Format different definitions:

Range of motion.

Joint mobility can be defined as the available amount of movement that a certain joint can complete without any restrictions

Neural mobility is referred to as the available range that a nerve can elongation or slide.

Flexibility and Myofascial mobility is the ability of soft tissue structures such as muscle, tendon and connective tissue to elongate through the available range of joint motion.

Neuromuscular Control Training or neuromuscular activation exercises can be defined according to the definition of Risberg *et al.* (2001) as "training/exercise stimulus that enhances unconscious motor responses by stimulating both afferent signals and central mechanisms responsible for dynamic joint control"(Risberg et al., 2007).

Riemann *et al.,* (2002) define neuromuscular control as the unconscious activation of dynamic restraints occurring in preparation for and in response to joint motion and loading for the purpose of maintaining and restoring functional joint stability (Riemann & Lephart, 2002a).

Proprioception is a sense or perception, usually at a subconscious level, of the movements and position of the body and especially its limbs, independent of vision; this sense is gained primarily from input from sensory nerve terminals in muscles and tendons (muscle spindles) and the fibrous capsule of joints combined with input from the vestibular apparatus (Riemann & Lephart, 2002b).

Dynamic Joint Stability can be defined as the state of a joint remaining or promptly returning to proper alignment through an equalization of forces (Riemann & Lephart, 2002a).

Reactive Neuromuscular Control Training is to facilitate the unconscious process of interpreting and integrating the peripheral sensations received by the central nervous system (CNS) into appropriate motor responses (Guido et al., 2007).

Functional Movement Patterns: FMP can be seen as the unconscious response of the central nervous system to control a joint in the safe neutral zone within a dynamic environment.

Muscular Strength Training was defined by Zatsiorsky and Kraemer at al., 2011 as a type of physical exercise modalities that specializes in the ability of the body to overcome or counteract external resistance by specific muscular effort (concentric, eccentric or isometric muscular contractions).

Muscular Strength Endurance is the ability of a muscle or muscle group to exert force to overcome a resistance numerous times. Often the resistance is the body itself. The measurement of muscular endurance is based on the number of repetitions performed.

Muscular Strength Hypertrophy involves an exercise stimulus that will provide an increase in size of skeletal muscle through a growth in size of its component cells.

Muscle Strength: Power is defined as the amount of work performed per unit of time. The ability to exert a maximal force in as short a time as possible, as in accelerating, jumping and throwing implements.

Functional/ Integrated/Complex training is a classification of exercise which involves training the body for the activities performed in daily life or sport.

Cardiovascular training: The ACSM defines cardiovascular exercises as those that are rhythmic, continuous and performed with large muscles of the body. These exercises include such activities as walking, jogging, cycling, swimming, hiking, stair climbing, rope jumping, cross-country skiing, skating, rowing and dancing.

Plyometric training: The term plyometrics refers to the increase of the expression of concentric strength that occurs following a rapid eccentric contraction (due to the stretch reflex).

7.3 Program content definitions and formulas:

There are many health professionals who prescribe resistance exercise to individuals, irrespective of whether the purpose is rehabilitation following injury or surgical intervention, for a healthy and active lifestyle or for elite performance, the scientific basis for exercise prescription is rarely evident. Professionals can fail to apply even basic principles of resistance exercise prescription in the years after their training on the principles and their practical implementation. Many professionals will remember students who load the client with the nearest weight and instruct them to do 10 repetitions. No rationale is provided for the choice of resistance load (determining the intensity of the exercise), its point of application to the patient, the number of repetitions to be performed or the end point of a set of repetitions (efforts), nor a demonstration or explanation of the technique that the patient/client should replicate.

In 2006 Toigo and Boutellier (2006) reiterated the six “classic” mechano-biological determinants of resistance exercise stimuli (or principles of resistance exercise prescription) and proposed seven new descriptors. The “classic” determinants were:

x1 load magnitude

x2 number of repetitions

x3 number of sets

x4 rest in-between sets [(s) or (min)]

x5 number of exercise interventions [per (d) or week]

x6 duration of the experimental period [(d) or weeks]

The additional (new) descriptors were:

x7 fractional and temporal distribution of the contraction modes per repetition and duration (sec) of one repetition

x8 rest in-between repetitions [(s) or (min)]

x9 time under tension

x10 volitional muscular fatigue

x11 range of motion

x12 recovery time in-between exercise sessions [(h) or (d)]

x13 anatomical definition of the exercise (exercise form)

While the theme of the article by Toigo and Boutellier (2006) was the molecular and cellular mechanisms by which training adaptations occurred, the determinants were obvious criteria enabling specific exercise prescription. This material will be taught in theoretical lectures and reinforced in practical sessions.

The aim of the practical sessions is not for students to achieve a significant increase in strength, power or endurance, but to experience the effort that they will be asking patients to make, to implement valid assessments and to prescribe resistance training appropriately for the goal they are setting. Most students who are inexperienced in resistance exercise training in a gym setting are set the goal of increased strength in a particular muscle group or movement.

7.3.1 Exercise Descriptors

Descriptor X1: Explanation of the Exercise – anatomical definition and description of the exercise (exercise form)

The muscle group and exercise machine included in the title can be repeated but it is more useful to include images or figures to illustrate how the client exercises on the exercise machine. In particular the images should illustrate the start position and the stop position. The start position should display how the client is positioned on the exercise machine prior to commencement of the first muscle action, and a statement of what that muscle action is.

Exercises are comprised of repetitions of a cycle consisting of two phases. For example, on the knee extension machine, the start position has the leg flexed prior to the first phase involving a concentric muscle action of the knee extensors that moves the leg to an extended position (perhaps near full knee extension). The second phase begins from the phase one finish position (stop position) and involves a controlled return to the start position with the knee

extensors working eccentrically. In the bench press exercise, the start position has the upper extremities extended straight holding the bar and weights. The first phase, involves eccentric muscle actions as the bar is lowered to touch the chest (the phase one finish position or stop position). The second phase, involves an upwards press from the chest to the extended upper extremities position using concentric muscle actions of the involved muscle groups.

As the overarching aim of the framework is to provide sufficient information so that a different student (or clinician) can read the documentation and implement an identical assessment or training session with the client, detailed information should be provided.

Professionals prescribing resistance exercise will require repetitions of the exercise to be performed with “good technique” and this typically means “with control through the range of motion”. Aspects of what constitutes a controlled performance with good technique should be stated (operationally defined), including the exercise cadence and expected time to complete the repetitions prescribed. “Trick movements” or substitutions to avoid may be useful information to convey to some clients. A demonstration of the exercise is often useful.

The instructions that are given to the patient should also be written in full on the spreadsheet. This information should cover the purpose of the exercise and be stated in terms that can be easily understood by the client.

Descriptor X2: Position(s), or Range of Motion [ROM]

The range of motion (ROM) must be specified. Considerations such as whether there is a mechanical limit at one end of the movement ROM should also be noted.

A very important consideration is whether the client completes the specified ROM. This is often critical because the design of many isolated joint exercise machines, and fatigue, results in the client failing to achieve the specified ROM. In isolated joint exercises such as exercising the knee extensors on a knee extension machine, failure occurs in the weakest part of the ROM, at full knee extension. Movement through the first phase occurs when the moment of force produced by the muscle group acting concentrically exceeds the moments of force due to resistance loads. When the angle-specific muscle moment equals the resistance moment, the muscle is only able to produce an isometric muscle action. As the muscle fatigues, or as motivation and activation is reduced, the isometric muscle action (stop angle) is achieved earlier in the ROM (further from end of the passive ROM).

For assessments of muscle strength, it is essential that the movement occurs through the specified ROM for a repetition to be valid. Practically, the stop angle is rarely the end of the ROM.

For multiple joint exercises, there may be a “sticking point” within the ROM in addition to (or rather than) a weaker range at the end of ROM (e.g. in a bench press). Again, achieving the specified ROM is critical in determining if a repetition is valid, and therefore to the determination of a “repetition maximale” (RM). The section on Descriptor 3 – Load Magnitude will expand on the RM concept.

One convenient way to establish the end of the operational ROM is to place a mark on the weight stack tracking frame (that is equivalent to the end of the operational ROM) that must be reached. For example, in the “Lat Pulldown “ exercise, the end of ROM may be set as pulling the unloaded (or lightly loaded) bar down until it is level with the xyphoid process. The height of the top of the weight stack is marked on tape that is affixed to the weight stack tracking frame. When increased loads are added for assessment or training, a repetition is only counted as complete if the weight stack rises to this level. Two incomplete repetitions or volitional cessation of the exercise validates the number of completed repetitions. Provided the patient’s starting position does not change between sessions, this mark on the weight stack tracking frame is used in future assessments and training sessions.

Descriptor X3 – Pretraining Assessed, Predicted or Estimated 1RM Load (kg)

The rationale for this descriptor is that the load magnitude should never be an arbitrary choice, but be based on a prior assessment. While there may be a number of ways in which muscle performance may be assessed, a common approach is to use the “repetition maximale” (RM) concept proposed by DeLorme (1945). A 1RM effort is the load magnitude that can be moved through the specified ROM with good technique once (but not twice). If a client can perform 4 repetitions through the specified ROM with good technique, the load magnitude would be termed a 4RM load, or a 4RM exercise. Generally, the RM concept is valid for between 1 and 10 maximal efforts (1RM to 10RM). This is because 1RM is moderately to strongly (linearly) related to 2 to 10RM efforts. After 10 repetitions the relationship becomes curvilinear, with a less accurate prediction of 1RM strength. A simple formula allowing the prediction of the 1RM load magnitude is:

% of a 1RM load = 100 – (2.5 * ? Repetition Maximum)

? RM is the number of repetitions completed according to the exercise criteria before performance failure. For example, if a client achieved 4RM (completes 4 repetitions, but could not complete a fifth repetition) against an external resistance of 32.5 kg of force, the formula would be:

% of a 1RM load = 100 – (2.5 * 4RM)

i.e. % of a 1RM load = 100 – (10)

i.e. % of a 1RM load = 90 %

The next step in predicting 1RM is to state the following:

If 32.5 kg of force is the resistance for 90% of 1RM

How many kg of force is the resistance for 100% of 1RM

kg of force = 32.5 * 100/90

i.e. # kg of force = 36.1 kg

This formula is reasonably accurate for most muscle groups, however more specific formulae can be found in the literature. Increased accuracy can be facilitated by more sensitive adjustments in the resistance loads.

Descriptor X4 – Load Magnitude (kg) [LM]

The intensity of effort is the single most important factor in determining the magnitude and rate of change in strength. It is thought that a greater training volume of a lower intensity of exercise may improve the strength gain, so the training volume is also important.

An absolute value of the resistance load magnitude (e.g. 30 kg) provides limited information on the intensity of the efforts that will be required to perform the exercise. It is useful to know both the absolute load and the relative intensity that the load requires. A concept to provide a relative intensity value is provided in the simple formula described in Descriptor X3.

Thus, if “a 6RM load of 30 kg” were stated, the relative intensity of the efforts can also be determined (6RM = 100% – (6 * 2.5 %) = ~85% (of the weakest point in the concentric phase of movement).

Some exercise programs report loads as percentages of an ?RM load; for example, 75% of a 10RM load. The implication of this description is much clearer when re-calculated as a proportion of a 1RM load, even when 1RM load has not been assessed but has been estimated or predicted. Thus, 75% of a 10RM load would be recalculated as 75% of a (100 – (2.5 * 10) % of a 1RM load, that is, 75% of 75% of a 1RM load, or 56% of predicted 1RM load.

While it is often reported that someone exercises at 1RM, or at 100% of an 8RM load (i.e. 8RM), is a 1RM really maximal? In fact, very little of the time spent in exercise is at 100% of the muscle’s capacity. A muscle only works at 100% when it generates a maximal effort moment that is matched by an equal (but opposite in direction) resistance moment. The muscle moment is a function of the muscle tension produced. The tension generated varies according to its activation, the length (joint angle) of the muscle (length-tension relationship) and the speed of the movement (force-velocity relationship).

In addition, the first of 8 repetitions of an 8RM exercise is at 80% of 1RM, the second repetition at a slightly higher relative effort, etc, increasing to the eighth repetition when the effort is maximal by definition (it is the eight repetitions with an 8RM load), but only maximal at the weakest position in the ROM.

Descriptor X5 Tempo – fractional and temporal distribution of the contraction modes per repetition and duration(s) of one repetition

Dynamic repetitions involve at least two phases; a concentric and an eccentric phase. At their simplest, a repetition is either a concentric effort followed by an eccentric effort (e.g. knee extension exercise), or an eccentric effort followed by a concentric effort (e.g. bench press exercise). The isometric phase that must exist between the phases as the movement changes direction would be considered too brief to be of significance. The time taken for the concentric and eccentric phases are then recorded.

Alternatively, isometric phases between the concentric and eccentric phases, and between the eccentric and concentric phases may be specified. They typically occur at the beginning of the concentric and eccentric phases. An exercise could contain four phases; isometric, concentric, isometric and eccentric phases. The times taken for all phases are then recorded.

Timing of exercises is aided by using a metronome that will count out beats at the set cadence. A recent resistance exercise trend is to program an eccentric phase that is twice as long as the concentric phase. The participant might perform the exercise with a two-beat concentric phase, followed by a four-beat eccentric phase, at a cadence of 72 beats per minute.

Knowledge of the temporal distribution allows a more accurate estimation of the intensity of effort and the energy systems contributions that will be required for performance.

Descriptor X6 – Duration of the experimental period [(d) or weeks]

Typically, how many weeks or months the program is expected to commence. The word “experimental” may be substituted for “training” in a research study.

Descriptor X7 – Number of Repetitions per Set [R]

The relative load magnitude allows an estimation of the number of repetitions. For example, a 6RM load suggests that the client should achieve 6 repetitions. A lack of motivation or earlier fatigue may mean that 6 repetitions cannot be completed, while a training adaptation may mean that the client is now able to achieve 7 or 8 repetitions, before performance failure

If the exercise prescription specifies a constant number of repetitions, the repetitions can be written into the training record ahead of their performance. If however, the repetitions are performed to performance failure, the performance must occur so that the number of repetitions can then be recorded.

If an instruction to “perform the maximum number of repetitions you can” is given for the first set, then this performance also serves as an assessment. That is, if the training exercise is carried out using the same instructions and to the same specifications as an assessment of strength, then it can suffice for an assessment. For example, if a resistance load estimated to be a 6RM is prescribed and the client performs 8 repetitions before performance failure in their first training set with this load, then that load is actually an 8RM load. The absolute resistance weight in kg can be adjusted up for the next training occasion (requiring 6RM efforts) can be calculated by multiplying by 0.85/0.80. The calculated absolute resistance weight will be the new 6RM resistance load.

The number of repetitions may be set as a constant, or may be allowed to vary with fatigue.

Descriptor X8 – Time Under Tension [TUT]

While the intensity of effort is the single most important factor in determining the magnitude and rate of change in magnitude of strength training gains, a greater training volume of a lower intensity of exercise would be expected to increase the strength gain. Traditionally, training volume has been defined as a function of the number of sets and repetitions performed in a single training period or over a specified period. A relatively recent addition to the resistance exercise terminology is the “time under tension” (TUT) concept, that can be used as a more precise indicator of training volume. It can be calculated as the sum of the exercise periods for each set. Concentric and eccentric muscle activation times can be calculated as TUTconc and TUTecc.

Descriptor X9 – Rest in-between Sets

The rest time in-between sets are determined from the exercise time. It is important to consider the intensity of exercise, the energy system involvement, whether fatigue is expected during the session, and how much fatigue is desired. The rest time or rest period is often described in a Work:Rest ratio for sets (W:R sets).

Alternatively, a minimum time can be stipulated and might be allowed to vary depending on the participant’s perception of their preparedness for the next set. This procedure would minimize fatigue in the later sets. The rest time should be recorded.

If there is a rest period provided between sets then a Work:Rest ratio for sets (W:R sets) can be defined.

Descriptor X10 – Number of Sets [S]

Once a decision has been made about the type of resistance training program to be designed and implemented, and an assessment of muscle strength completed, the training intensity can be specified. A high intensity, low repetition strength training program is usually implemented with a higher number of sets so that an effective training volume may be achieved, for example, 7 sets of 4RM.

Conversely, a low intensity, high repetition strength training program is implemented with a lower number of sets so that an effective training volume may be achieved, for example, 4 sets of 8RM.

A low intensity, high repetition endurance training program is implemented with a lower number of sets so that an effective training volume may be achieved, for example, 3 sets of 20RM.

Descriptor X11 – Volitional Muscular Fatigue OR Was Performance Failure Achieved? [PF]

This criterion seeks to identify the cause of endpoint of the exercise and is recorded as a Yes or a No. If the answer is Yes, then fatigue is likely the reason for not being able to complete further repetitions. If No, then factors other than fatigue could be the reason. Some sets of exercise are designed with a set number of repetitions and without performance failure. For example, a client whose 1RM load is 50kg exercises with a 40 kg load (an 8RM load) may only perform sets with 6 repetitions. The client should not be fatigued in the last repetition and is therefore not working with maximal effort in any of the repetitions. Worse still, as a strength training prescription, is the client who exercises with a 30RM load and is instructed to complete 10 repetitions!

A Yes, or No answer to the question “was performance failure achieved” can be elicited from the participant for each set. Programs may be designed where the participant exercises to fatigue in every set. Other program designs may require the participant to exercise to fatigue in only the first set, or in only the last set.

Descriptor X12 – New Assessed or Predicted 1RM (kg) [New Pred 1RM]

Under certain conditions a training session can also be an assessment condition. When a strength training session incorporates a set (usually the first set) where 2 to 8RM (an appropriate load) of an exercise is performed with good technique until performance failure, it will suffice as a strength assessment. This assessment of ?RM strength enables the reassessment of a new (predicted) 1RM strength load magnitude.

Descriptor X13 – Number of exercise interventions [per (d) or week]

This descriptor is self-explanatory and describes the number of sessions per day or sessions per week.

Descriptor X14 – Recovery time in-between exercise sessions [(h) or (d)]

This descriptor specifies the time in-between sessions. Some training programs specify a time in days, or simply a minimum time.

The following two tables will elaborate on some secondary definitions that could potentially been used by a Biokineticist when in practice.

Training Program Design Principles	
Principal	**Definition**
Individuality	Treating the individual patient according to their special needs.
Progressive overloading/Load Progression	Progressive overload is the gradual increase of stress placed upon the body during exercise training.
Specificity	All training adaptations are specific to the stimulus applied and tailored to the demand.
Periodization of Rehabilitation	The rehabilitation process is driven by the manipulation of training variables that elicit specific adaptations in order to meet established goals.
Training Volume	Training volume is a summation of the total number of repetitions performed during a training session multiplied by the resistance used (kg) and is reflective of the period of which muscles are being stressed.
Compound sets	This training modality consists of performing two different exercises of the same muscle group in alternating fashion with little to no rest between exercises.
Tri-sets	Three different exercises performed one after another, without any rest in between.
Single sets	One exercise set performed for a certain amount of repetitions.
Super Sets	A superset is when two or more exercises hitting different muscle groups are performed in a row without rest between them.

Table 7.2 Definitions for effective program prescription

Optimal Loading Exercise Guidelines			
	Different Training Modes		
Loading Variables (X_1-X_{13})	**Neuromuscular Control/Activation Exercises**	**Strength Endurance**	**Strength Hypertrophy**
Load Magnitude	< 30 %RM	30-70%RM	> 70% RM
Number of repetitions	> 20 or 30-60 sec	12-15	8-12
Number of sets	3-5	3-5	2-4
Rest in - between tri-sets [(s) or (min)]	Rest= Work	Rest= 1.5 Work	Rest= 2 Work
Number of exercise interventions [per session (d) or week]	5 days in 7-day week	3-5 per week	2-3 per week
Fractional and temporal distribution of the contraction modes per repetition and duration (s) of one repetition	Isometric/concentric/ eccentric	4 sec con;4 sec ecc	1 Sec con:4 ecc
Rest in between repetitions [(s) or (min)]	N/A	N/A	N/A
Time under Tension [(s) or (min)]	90-320 Sec per Exercise	Sets*Repetitions* Contraction mode per rep (280-600 sec)	Sets*Repetitions* Contraction mode per rep (80-240sec)
Volitional Muscular Failure	Yes	Yes	Yes
Range of motion	Mid-Inner Range	Full	Full
Recovery time in between exercise sessions [(h) or (d)]	12-24h	48 H	48H
Anatomical definition of the exercise (Exercise Form)	Pictures	Picture	Picture
Adapted from Rathleff et al., 2016			

Table 7.3. Training descriptors adapted van Toige et al., 2006

7.4 Program outcomes different definitions

The following two definitions in 6.5 and 6.6 could be tracked in Step B-b1**.**

7.4.1 Clinical Status Indicator

Definition: A measure, process, or outcome used to judge a particular clinical situation and indicate whether the care delivered was appropriate.

Clinical status indicator can be tracked over the intervention period to determine if there was progression/regression in the clinical status of the patient when compared with initial assessment. This indicator will be measured daily to plan appropriate load adjustments for that specific day or if the clinical status indicator stays the same, load progression can follow.

7.4.2 Program adherence over intervention time

Definition: Adherence to intervention protocols refers to the degree at which the behaviour of the patient corresponds to the intervention assigned to them. It can be tracked in a supervised rehabilitation model to see if the minimal requirement of between 2-3 exercise sessions per week was accomplished to stimulate physiological adaptation on anatomical and central nervous system levels.

References

Dye, S. F., St, H. U., Biedert, R. M., & Vaupel, G. L. (1999). The mosaic of pathophysiology causing patellofemoral pain : therapeutic implications.

Mueller, M. J., & Maluf, K. S. (2002). Tissue adaptation to physical stress: a proposed "Physical Stress Theory" to guide physical therapist practice, education, and research. *Physical Therapy*, *82*(4), 383–403. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11922854

Riemann, B. L., & Lephart, S. M. (2002a). The Sensorimotor System , Part I : The Stability, *37*(1), 71–79.

Riemann, B. L., & Lephart, S. M. (2002b). The Sensorimotor System , Part II : The Role, *37*(1), 80–84.

Risberg, M. A., Holm, I., Myklebust, G., & Engebretsen, L. (2007). Neuromuscular training versus strength training during first 6 months after anterior cruciate ligament reconstruction: a randomized clinical trial. *Physical Therapy*, *87*(6), 737–50. https://doi.org/10.2522/ptj.20060041

CHAPTER 8

Planning for return to sport

Outcomes of this module

1. **Understand shared decision-making (SDM) within the context of multi-disciplinary communication**
2. **StaRRT model as a starting point**
3. **Importance of Functional testing in clinical practice**
4. **Interpreting the program outcomes measuring methods**
5. **Biokineticist's role within MD decision-making**

8.1 Understand shared decision making (SDM) within the context of multi-disciplinary communication

Previous injury is associated with up to a 4-fold increase in the risk of reinjury, and the treatment of all injuries includes advice on when it is safe to resume sport participation. For this reason, return-to-play (RTP) decisions are critical to the practice of clinical sport medicine. In the absence of clear scientific evidence, RTP decisions lack standardization (Fuller et al., 2007) and can be a source of confusion and disagreement for physicians, athletes, coaches, and administrators.

Return-to-play (RTP) decisions are complex, specific to the athlete and type of sport, and often influenced by 'decision modification' factors (e.g. pressure to return for a major event) (Creighton et al., 2010). In the case of a sprinter with a hamstring strain, 2 weeks from the World Championships, the final RTP decision-maker might be the athlete. However, the healthcare professional should be the final RTP decision-maker when athlete's decision making capacity is compromised (e.g. concussion).

Where an athlete has the capacity to make a decision, we propose (and use) a shared decision-making (SDM) process; this approach improves outcomes and satisfaction with treatment (Creighton et al., 2010). The three key steps in SDM are:

1. Choice: making the athlete and coach aware that reasonable options exist;

2. Option: providing more detailed information about the different options;

3. Decision: guiding the athlete and coach to consider his preference and decide what is best.

8.1.1 Role definition in sports medicine SDM that includes the three-key people in SDM (Fgure 6.1):

1. Healthcare professional: The most appropriate person to evaluate the health status of the athlete and provide objective advice on management options and possible clinical outcomes following RTP (case manager). This includes the short-term risk of performance detriment or reinjury, the consequences of reinjury and the long-term health (and performance) risk. The main goal of the health care professional is to prevent subsequent injuries and to prepare the athlete to pre-injury level of competition.

This advice is primarily based on the clinical situation, the context of the real athlete with a very specific problem. Professional experience, sport-specific injury and performance knowledge and a relationship with the individual athlete, framed by an understanding of the relevant published scientific evidence, are the important elements of the decision-making process. **In sport, this advice is usually informed by input from the supporting team of healthcare professionals who work with the athlete** (Dijkstra et al., 2017).

2. Athlete: When fully competent, the athlete should make an informed decision about his/her readiness and desire to RTP. This decision is based on personal circumstances and experience, his/her intrinsic view on risk taking, the environment and specific information regarding health and performance. Contextual factors that may be relevant to the athlete include sponsorship deals or media pressure. Despite the athlete's preference, at the highest level of elite sport, there are often wider performance implications with impact on other athletes in the team (and in individual events) that need to be considered (i.e. one rower causing a rowing 8 to fail). Therefore, the final decisions regarding selection, participation and RTP are not usually made in isolation. The athlete's input is a pre-requisite (Dijkstra et al., 2017).

3. Coach: The informed coach evaluates the current ability of the athlete to perform a specific required standard, based on knowledge of the athlete, the training missed, the athlete's functional progression in rehabilitation and the information provided by healthcare professionals. The coach's contribution to the RTP discussion relates to the sport-specific context. For example, the coach of an Olympic triple jumper will not use the same RTP criteria as the coach of an Olympic football or rugby sevens team. In elite sport, only the coach can place this current 'ability-to-perform' into the performance context of the upcoming opposition, event/match conditions, stage of the season, importance of the competition, impact on later competitions and the ability of potential replacements (Dijkstra et al., 2017).

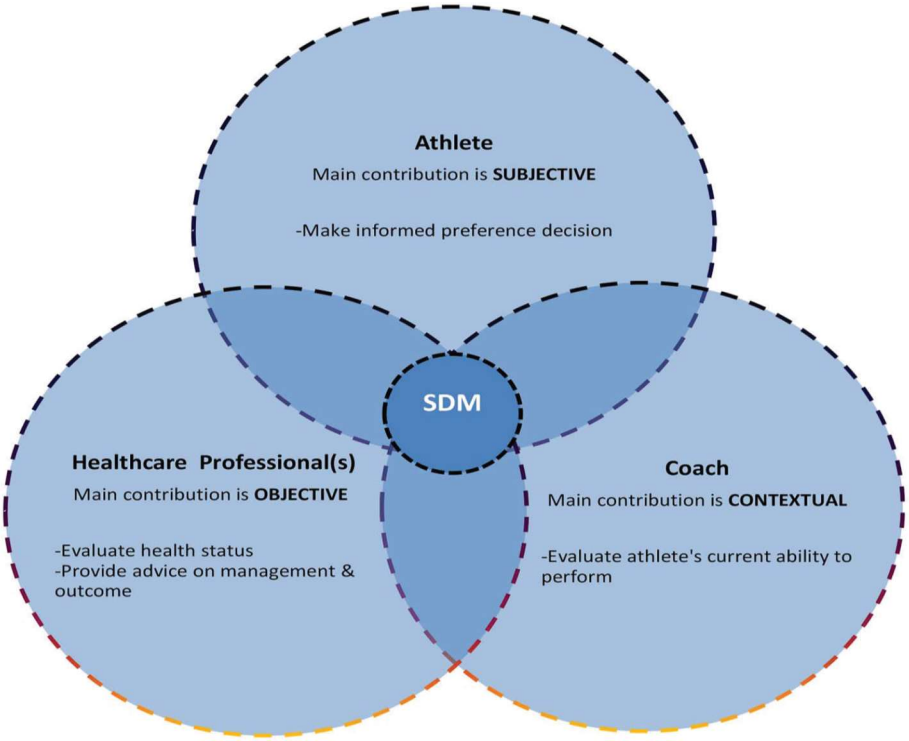


Figure 8.1 The size of the contributing circles to the shared decision-making (SDM) processes are influenced by different factors, including health status, participation risk and other decision modifiers (Dijkstra et al., 2017).

8.2 StARRT framework as a starting point

The Strategic Assessment of Risk and Risk Tolerance (StARRT) framework. The (StARRT) model is a three-step model that helps estimate the risks of different short-term and long-term outcomes associated with RTS, and factors that may affect what should be considered an acceptable risk within a particular context (Figure 8.2).

Successful SDM depends on effective communication within performance teams; clear and consistent ongoing communication is vital to achieve trust among the key people involved, and ultimately, the quality RTP decision (Ardern et al., 2017).

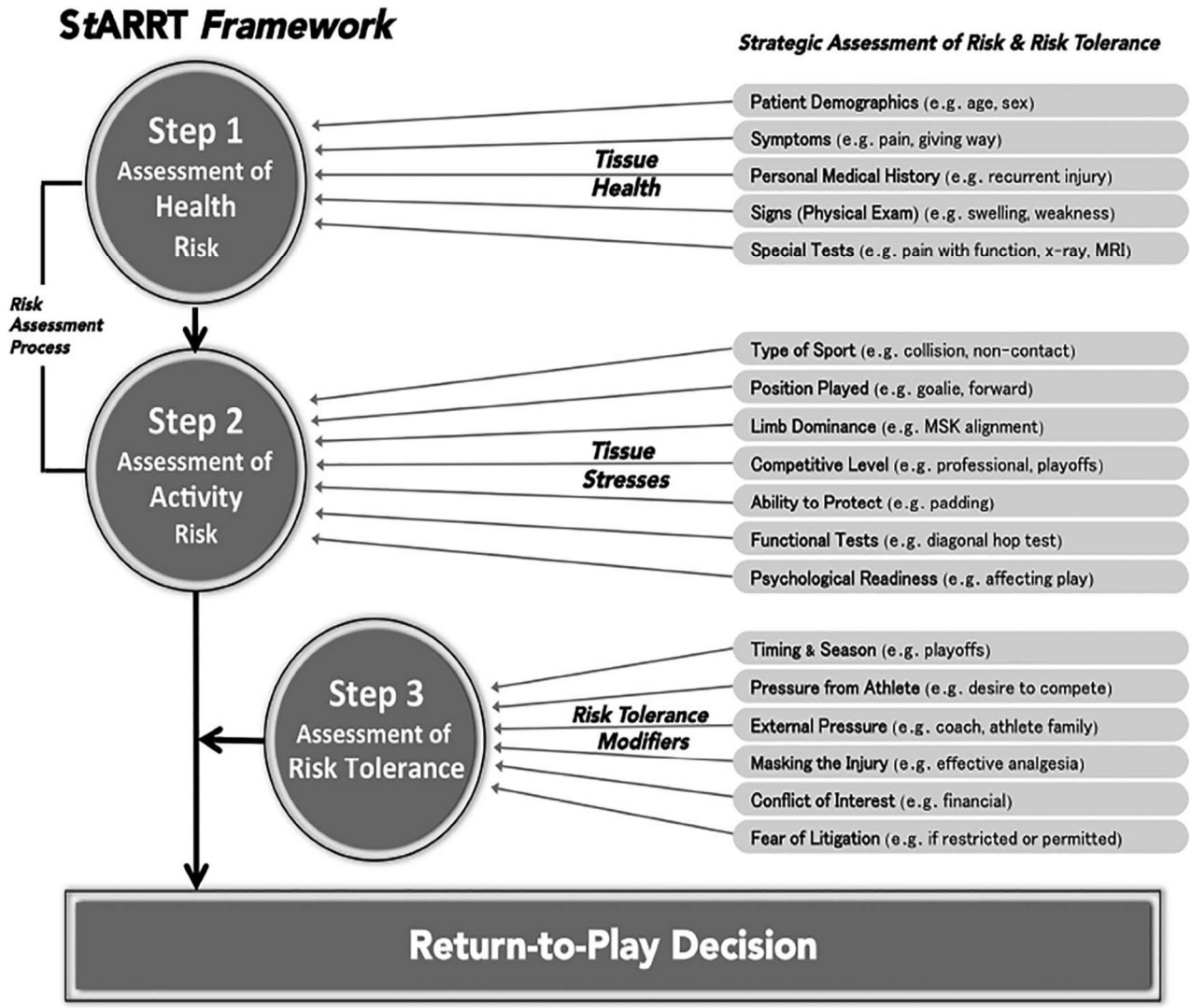


Figure 8.2 Decision-based RTP model. The decision-based RTP model for an injury or illness is specific to the individual practitioner making the RTP decision. The large black circles represent the state of nature elements (the circumstances under which a decision is made). The RTP square represents the final decision that actually results in an action being taken. The texts on the far right are individual factors or components identified from the literature that contribute information to the states of nature. These factors are grouped into Medical Factors, Sport Risk Modifiers, and Decision Modifiers and are on the left because they represent the general concepts the clinician should focus on when making a decision (the details are provided on the right). In Step 1, the health status of the athlete is assessed through the evaluation of Medical Factors. For example, symptoms, signs, and testing provide information on how much healing of the injury or illness has occurred. In Step 2, the clinician evaluates the risk associated with participation. For example, the health status is usually heavily weighted when the known reinjury and long-term sequelae risks are high (e.g. if an athlete participates with only partial healing). However, there are Sport Risk Modifiers that also affect the risk associated with participation. For example, it may be possible to protect the injury with

padding or to minimize risk by changing the position of the player. Although the RTP decision is fundamentally based on the risk associated with participation, decision-making in all fields is based on a risk–benefit balance. There may be benefits to an athlete that affect what is considered an acceptable risk. For example, play-off competitions may result in significant financial and nonfinancial gains. Accounting for these Decision Modifiers (Step 3) is the final step in the process that leads to the actual RTP decision. Decision Modification is set aside from the other steps because Participation risk does not contribute information about Decision Modification, and Decision Modification cannot be used to determine RTP except in the context of participation risk. Finally, the process is recursive; decisions to not clear an athlete for participation are revisited as the healing process continues, and decisions that allowed an athlete to play are revisited if symptoms or signs recur or if the status of any of the Sport Risk Modifiers or Decision Modifiers are changed.

8.3 Importance of Functional testing in clinical practice

Biokineticists should have the superior skill of designing rehabilitation programs and develop scientific reporting methods**. Interpreting the intervention data and transferring the most relevant contextually information to the appropriate stakeholders in the SDM process should be a mandatory characteristic of any Biokineticist**. This should be done in a format so that all on the SDM team members can understand it and so improve further relevant StaRRT decisions.

Why do we need to do functional testing in clinical practice?

1. Restore mechanical stability
2. Restore functional performance
3. Get patient back to pre-injury levels
4. Prevent a subsequent injury
5. Improve wellness and health

Does it add value into the current Biokinetic curricula?

1. If you can't measure -you can't manage
2. It can predict pre/post-operative progression or regression of individual patient outcomes
3. Can it predict future RTS/activity outcomes?
4. The data can be used for research purposes
5. It enables the Biokineticist to do injury/illness risk management

Controlled physical stress on the **INJURED STRUCTURE** is needed, within the envelope of function, to advance the processes of **HEALING** and neuromuscular adaptation. This should take place within a time-based as well as an individualized criterion-based rehabilitation progression model. (Vlok and Holtzhausen, 2014 unpublished)

8.4 Interpreting the program outcomes measuring methods

A patient-reported outcome (PRO) is a health outcome directly reported by the patient who experienced it. PRO's is being uploaded on the TRIPP software system to track subjective patient reported outcomes (Primary Outcomes) measurements after every mesocycle and reports can be generated from there.

Secondary outcome measurement goals can be set up at initial assessment and be reassessed after the intervention time has been completed. Results can be expressed as %LSI (injured compared to uninjured) as an estimated benchmark or progression from initial assessment. This measurement will indicate functional performance ability of involved structures when compared to uninvolved, or benchmark asymmetries, or progression/regression when compared to previous assessment.

1. LSI (Injured compare to uninjured*100/1) can be used to identify potential re-injury risk factors and a decrease in functional performance after injury/illness.
2. Benchmark: A measurement of the quality and the quantity of the movement and then the comparison with standard measurements, or similar measurements of its peers.
3. Progression/regression assessment on the primary and secondary outcomes measurements will follow a re-evaluation.
4. Performance Indicators=100%-(LSI/Benchmark)

All the above mentioned measurement tools will be incorporated in the TRIPP software system to track patient results and give feedback on these outcomes.

8.5 Biokineticist role within MD decision-making.

The primary role of the Biokineticist within the MD team is to enable the clinical council, with its case manager, to make better decisions for better patient management and return to activity considerations.

References

Ardern, C. L., Glasgow, P., Schneiders, A. G., Witvrouw, E., Clarsen, B., Cools, A. M., … Bizzini, M. (2017). Infographic: 2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *British Journal of Sports Medicine*, *51*(13), 995–995. https://doi.org/10.1136/bjsports-2016-097468

Creighton, D. W., Shrier, I., Shultz, R., Meeuwisse, W. H., & Matheson, G. O. (2010). Return-to-play in sport: a decision-based model. *Clinical Journal of Sport Medicine : Official Journal of the Canadian Academy of Sport Medicine*, *20*(5), 379–85. https://doi.org/10.1097/JSM.0b013e3181f3c0fe

Dijkstra, H. P., Pollock, N., Chakraverty, R., & Ardern, C. L. (2017). Return to play in elite sport: a shared decision-making process. *British Journal of Sports Medicine*, *51*(5), 419–420. https://doi.org/10.1136/bjsports-2016-096209

CHAPTER 9

Why Outcomes, Why Now?

Outcomes for chapter

1.Define outcomes

2. Understanding outcomes assessment and outcomes management

9.1 Introduction

In my personal experience over 1 years as a Biokineticist in private practice, I could not convince myself that by only asking the following question to the patient, “How do you feel, yes I feel better”, that I have achieved long-term success with my treatment strategy.

A patient centred philosophy based on evidence-based practice (EBP) was the key to my never-ending continual struggle to answer questions like: “How far are we from finishing the rehabilitation, when can I run/play again, do I(patient) get better, what do you (Biokineticist) think?”. “Did I manage to change the scoreboard at the end?”, was the continual persisting question that was chasing me.

From a personal note, after implementing an outcomes measures model in my practice, I have observed many benefits, most notable was my ability to identify with confidence the endpoints of care and the accurate predictions on the success/failure of exercise as an intervention for the different fields of rehabilitation. This approach leads our practice to be more focused on what is necessary in terms of treatment specifics for the individual patient.

9.2 Outcomes Measurements

Outcomes can provide needed tools to focus patients on meaningful treatment goals more effectively.

Departed are the days when Biokineticists would dictate what they felt patients needed without actually doing the measurement and display the data for further analysis. In approaching this new environment of measuring outcomes, we need to understand two theoretical definitions 1) Outcome assessment and 2) Outcome management:

9.2.1 Definition of Outcomes assessment:

Collecting or recording of information relative to the health processes. Outcomes Assessment in clinical practice provide the mechanism by which the healthcare provider (HCP), the patient and the financier (Medical Aids) are able to access the end results of care and its effect upon the health of the patient and society.

9.2.2 Definition of Outcome Management:

Using the information in a way that enhances patient care. Routine incorporation of clinical and administrative measurements of quality will be another expectation of Biokineticists in the near future, demanded by third party stakeholders.

The health care system is positioned and poised to assess the efficacy of individual practitioners and their ability to deliver cost-effective, quality health care. To survive, in fact to flourish in the era of accountability, Biokineticists must be prepared to maintain and be able to provide appropriate documentation and patient records in a clinically efficient and economical manner. Outcome management is essentially a tool that helps Biokineticists to focus on what is important to the patient's life.

We believe that Biokineticists are positioned at the center point of measuring treatment effectiveness because we are the only Allied professionals who can measure outcomes over time in exercise as a primary intervention. This should be embraced by the profession because:

1. We will be outside the binoculars of the Physiotherapy departments in terms of scope of practice.
2. We will provide effective intervention data to Medical Aids on intervention progression/regression.
3. We will give EBM feedback to insurance brokers and other team management staff on when players are ready for what.
4.We will educate the patient about re-injury risk and possible performance inhibitors and provide objective patient feedback.
5. We will be able to provide sensitive information to inter-professional management, like orthopaedic surgeons, which could lead to quality decision-making on further intervention.

9.2.3 Understanding the process of measuring outcomes.

This process could be documented in a simple process that we will discuss in the following format. First of all, we need to adhere to the prognosis of the injury/disease/illness and the responses to physical exercise**. To accomplished that we need to find out based on solid EBM research if exercise could be used as a primary/secondary/maintenance intervention strategy.** Duplicating the intervention from research platforms could enable Biokineticists to make sound EBM decisions within the inter- professional team. Outcomes can be tailored to the return to sport continuum with return to participation the entry level and return to performance the highest level of sport participation. Selecting PROM's and PBOM's should direct the Biokineticist in the right direction when the patient is accepted into rehabilitation for a specific condition out of the 10 fields of rehabilitation. These outcome

measures should be a breakdown of the specific demands on the return to sport continuum and reflect the specific demands placed on the systemic or non-systemic systems.

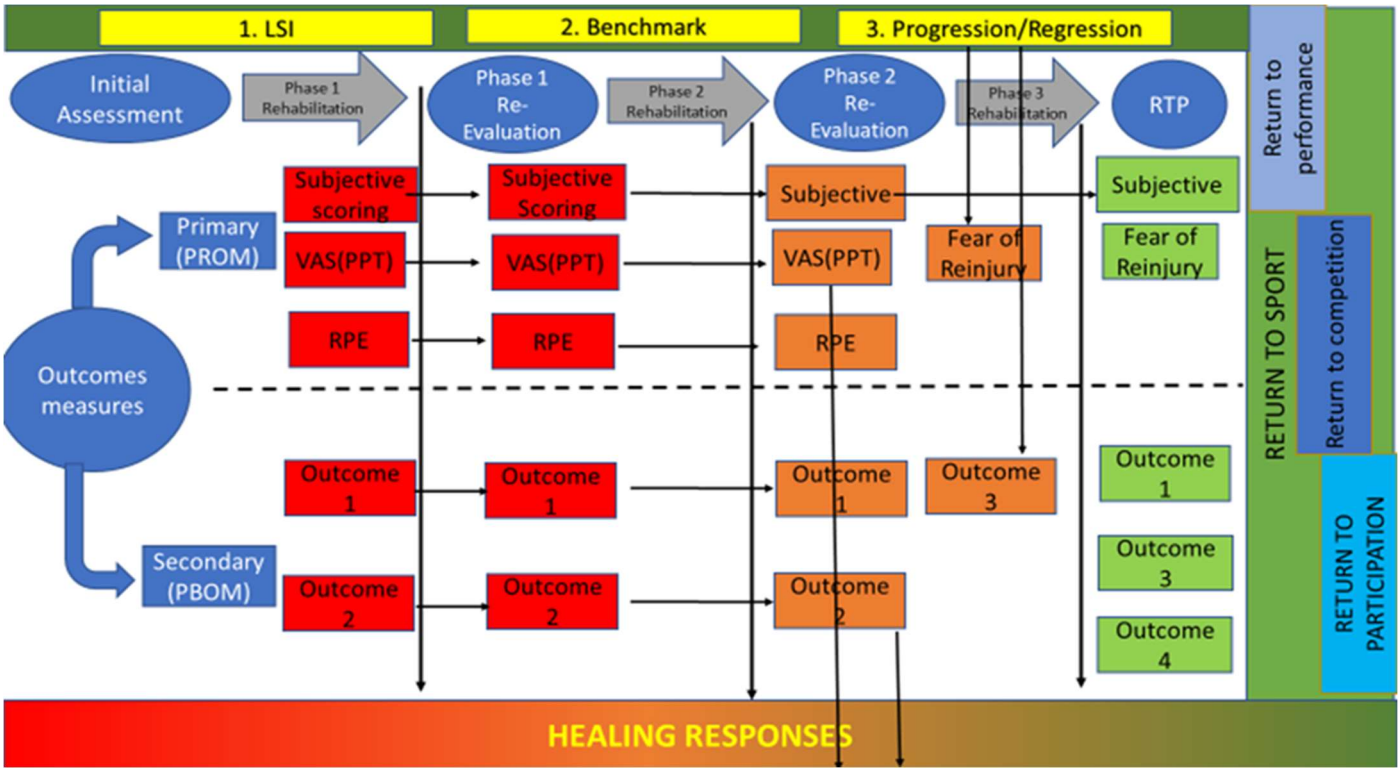
9.3 The process of measuring PBOM's and PROM's (Look at the end of page).

The effective planning of the right PROM's and PBOM's and the management of these outcomes measures within the context of EBM can be observed as a science within the exercise is medicine domain. The main purpose of this process is to optimally load the injured structure or system to improve physiological adaptability in the desired system, to improve the physical well-being of the patient.

This process starts with the healing responses (Bottom of Diagram) and the return to sport demand (Right side on diagram). These two components can only effectively be managed within measurements of the outcomes measures (Left). The results of the particular outcomes can be expressed as the difference between injured and uninjured (LSI), or compared to a benchmark in the particular outcome and lastly progression/regression of the outcomes can be measured (Top of diagram).

In the initial assessment the PROM's (Subjective scoring sheet or/and VAS or/and RPE) and PBOM's (Musculoskeletal or/and Clinical Outcomes) will be selected within the context of the initial clinical status of the injured structure or the severity of the current illness or disease. Thereafter, a phase 1 rehabilitation intervention consisting of X amount of sessions will be implemented over a Y number of weeks. Subsequently, the progress assessment 1 which will be primarily a duplicate of the initial assessment, will follow. Calculations of the differences between PROM's and PBOM's and Clinical Status indicators at initial and progress assessment 1 could be extracted. This information can be expressed in either LSI, benchmark or progression/regression. The MCID can be calculated within certain PROM's and PBOM if the values are supplemented by good, relevant research. Certain new PROM's or PBOM's can be inserted, depending on the clinical status of the injured structure or severity of the illness/disease. Some PROM's and PBOM's may fall away because for that specific test the patient accomplished the goal at that specific level (Vertical solid lines moving out of diagram). A phase 2 intervention programme may be launched, if the results of progress 1 assessment is indicative of it. Progressively we overload certain structures and systems to improve its ability to handle more of the applied load and thus increase loadbearing capacity to the point of the predetermined demand (far right on diagram). Progress assessment 2 will be a duplicate of progress 1 with some minor changes to the outcomes. RTP (last block on the right of diagram) testing will only be an extension of the current process.

Figure Proposed Progress Assessment Framework


1. LSI
2. Benchmark
3. Progression/Regression
Initial Assessment
Phase 1 Rehabilitation
Phase 1 Re-Evaluation
Phase 2 Rehabilitation
Phase 2 Re-Evaluation
Phase 3 Rehabilitation
RTP
Return to performance
Outcomes measures
Primary (PROM)
Secondary (PBOM)
Subjective scoring
Subjective Scoring
Subjective
Subjective
VAS(PPT)
VAS(PPT)
VAS(PPT)
Fear of Reinjury
Fear of Reinjury
RPE
RPE
RPE
RETURN TO SPORT
Return to competition
Outcome 1
Outcome 1
Outcome 1
Outcome 3
Outcome 1
RETURN TO PARTICIPATION
Outcome 2
Outcome 2
Outcome 2
Outcome 3
Outcome 4
HEALING RESPONSES