Clinical Reasoning in Exercise and Rehabilitation
# Clinical Reasoning in Exercise and Rehabilitation

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How to use this booklet

Much of the work covered over the 2 contact blocks of this course will require a basic knowledge of the subject areas. Revision of anatomy, physiology, biomechanics covered at under-graduate level will help you understand some of the terminology used and concepts discussed in the contact sessions.

The following individual study will allow full participation in the study days. However, there are self study guides included in this booklet to help guide your revision. It is **not expected that you must learn all of this prior to the courses**.

The sections are split into some exercise physiology, biomechanics and motor control. They contain a mix of background information and directed tasks. Some “little gems” have also been highlighted. Through the etxt you will see one or two symbols repeated to quickly guide you.

Denotes a task intended to allow you to check your knowledge. If you can’t answer the questions you need to go back to your basic text books to remind yourself.

Denotes useful bits of information.
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PHYSIOLOGY

Revising some of the basic exercise physiology principles will help you to be able to participate in the discussions during the course.

The worksheet below will help guide your pre-course reading. Most of the content will be familiar but you will find the information in any basic physiology text should you need to do some revision. The information supplied here is from McCardle, Katch and Katch. Exercise Physiology.

ENERGY PROVISION

ATP is the energy currency, it is involved in the following types of functions:-

- Mechanical muscle work (muscle contraction)
- Synthesis or re-synthesis at cellular level
- Transport of material

STRUCTURE OF ATP

High energy phosphate bonds

\[ \text{Adenosine} \cdot \text{O} \cdot \text{P} \sim \text{O} \cdot \text{P} \sim \text{O} \cdot \text{P} \sim \text{OH} \]

\[ \text{OH} \quad \text{OH} \quad \text{OH} \]

Only very small amounts of ATP can be stored in the body at any one time. As it cannot be replenished by blood supply it has to be resynthesised.

List some of the possible fuel sources of ATP
Phosphocreatine/ Creatine Phosphate (PCr/CP)

Creatine phosphate is found in muscle and is considered the high energy phosphate reservoir. Outline the importance of phosphocreatine in energy production during exercise.

OXIDATIVE PHOSPHORYLATION

\[
\text{NADH} + \text{H}^+ + 3\text{ADP} + 3\text{P} + \frac{1}{2} \text{O}_2 \rightarrow \text{NAD} + \text{H}_2\text{O} + 3\text{ATP}
\]

Phosphorylation is the process by which energy is transferred in the form of phosphate bonds, resulting in the resynthesis of ATP and CP.

The body’s source of nutrients can come from carbohydrates, fats or proteins. Carbohydrates are stored in the liver and muscle as glycogen. The glycogen molecules can be broken down by glycolysis which is an anaerobic reaction. (Fig.1)

Following glycolysis, the pyruvate can then either pass through to the inside of the mitochondria for oxidation via Kreb’s cycle (in the presence of oxygen) or converted to lactate in the muscle.

Fats can be broken down through the fatty acid metabolism but only in the presence of oxygen. Proteins can be broken down through deamination where the nitrogen is removed from the amino acid molecule then via Kreb’s cycle.

McCardle et al describes glycolysis and the Kreb’s cycle in Chapter 6.
What are the 3 types of processes that produce ATP?
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What are the main differences between anaerobic and aerobic carbohydrate metabolism? What are the advantages and disadvantages of both?

Think of some sports that you are familiar with. What are the predominant metabolisms in those activities – or is there a mixed requirement in some sports?

You should have been able to list the immediate energy system (ATP-CP), short term energy system (lactic acid), long term energy system (aerobic).

ATP-CP resource would be depleted after approx 6 secs of all out activity. To continue producing energy for high intensity exercise the main sources are blood glucose and muscle glycogen metabolised anaerobically, producing lactic acid. At maximum intensity, the lactic acid system would be exhausted in 3-4 mins.

This mechanism buys time for respiration to be stimulated to increase oxygen uptake in preparation for aerobic activity thus reducing lactate levels providing that the exercise was at a sustainable level. Lactic acid starts to accumulate at approx 55% VO\textsubscript{2} max. in healthy untrained individuals and the point at which this occurs is termed the onset of blood lactate accumulation (OBLA). With training, the aerobic system is able to cope at higher levels of intensity, thus delaying OBLA and the ensuing fatigue.

In steady state exercise, which is predominantly aerobic, lactic acid accumulation is minimal. A trained person will reach this steady state more rapidly, thus reducing the oxygen debt. [If any of these terms are unfamiliar, you may need to revise this section of your exercise physiology text].
What is VO\textsubscript{2} max?

Why is moderate exercise during recovery thought to facilitate the recovery process?

Think of a familiar sport again. Can you think of any incidences of injury where the injury occurred through inappropriately targeted training of the different energy metabolisms?

MUSCLE PHYSIOLOGY

These principles should be familiar to you but if you cannot answer the questions included in the tasks, you will need to revise some of the concepts.

What are the main muscle fibre types and their characteristics?
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The table below should help jog your memory

<table>
<thead>
<tr>
<th></th>
<th>Type I fibres</th>
<th>Type IIA fibres</th>
<th>Type IIB fibres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraction timing/twitch</td>
<td>Slow</td>
<td>Fast</td>
<td>Very Fast</td>
</tr>
<tr>
<td>Motor neurone size</td>
<td>Small diameter</td>
<td>Large diameter</td>
<td>Very large diameter</td>
</tr>
<tr>
<td>Mitochondrial density</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Capillary density</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Dominant substrate</td>
<td>Triglycerides</td>
<td>CP, Glycogen</td>
<td>CP, Glycogen</td>
</tr>
<tr>
<td>Fatigue resistance</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Force production capacity</td>
<td>Low</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Typical activity</td>
<td>Aerobic</td>
<td>Prolonged anaerobic</td>
<td>Short anaerobic</td>
</tr>
</tbody>
</table>

Types of muscle work

As a revision, the following table summarizes the 3 muscle actions (modified from Trew and Everett 2005)

<table>
<thead>
<tr>
<th>Contraction type</th>
<th>Function</th>
<th>External force relative to internal</th>
<th>External Work</th>
<th>Relative force generated</th>
<th>Energy cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isometric</td>
<td>Fixation</td>
<td>Same</td>
<td>None</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Concentric</td>
<td>Acceleration</td>
<td>Less</td>
<td>Positive</td>
<td>Lowest</td>
<td>Highest</td>
</tr>
<tr>
<td>Eccentric</td>
<td>Deceleration</td>
<td>Greater</td>
<td>Negative</td>
<td>Highest</td>
<td>Lowest</td>
</tr>
</tbody>
</table>
Can you define the following terms?

Stabilizers

Synergists

Fixators

Describe the characteristics of the following muscle types:

Phasic

Tonic

What are the main points in the sliding filament theory of muscle contraction?

Describe the principles of the overload principle in strength training.
KINAEOSIOLOGY

The following section covers some of the basic principles of kinaesiology. This will be a revision of undergraduate physiotherapy core skills and should serve as a reminder of typical terminology used in this area. You should be able to answer the questions in the tasks. If not a good source of further reading to revise these concepts can be found in van Deursen (2006) in Trew and Everett (2006) Human Movement. Elsevier. The following information is modified from this book chapter.

NEWTON’S LAWS OF MOTION

1. LAW OF INERTIA

Every body continues in a state of rest or uniform motion in a straight line except when it is compelled by external forces to change its state.

2. LAW OF ACCELERATION

The rate of change of momentum of a body is proportional to the applied force and takes place in the direction in which the force acts.

3. LAW OF ACTION/REACTION

To every action there is an equal and opposite reaction.

These three laws form the basis of many principles of exercise prescription and progression.

DEFINITION OF FORCE

A force can be defined as:

An influence that changes the state of rest or motion of a body or object

(van Deursen 2006)
Name three terms that can describe a force

Can you write the equation for force based on Newton’s laws?

FORCE ANALYSIS

There are two basic terms used to describe force (or vector) quantities.

summation - involves adding the force vectors to find the resultant or the force that could replace the combined effect of all the forces acting on the body.

resolution - Splitting a force into its components to establish its effects in two or three principal directions is called resolution of forces.

SOME TYPES OF FORCES

GRAVITY

The force of attraction of the earth to any object on or near to its surface. The weight of an object is the force exerted by the earth on the mass of the object or

weight = mass * 9.81 (acceleration due to gravity).

This is expressed in Newtons.
GROUND REACTION FORCE

Ground reaction force is the force of the ground, acting on the body thus opposing the effect of gravity. This is based on Newton’s third law of motion:

FRICIONAL FORCES

When two objects move, or tend to move, over each other they experience a resisting force. This force is referred to as frictional force and occurs if the objects are solid, fluid or a combination of both.

PRESSURE

Pressure is comprised of force but relative to the surface area over which the force is acting. Pressure can be defined as the force per unit area or:

Pressure = Force/Area

It is measured in N/m²

LEVERS

A lever is defined as:

A rigid bar that rotates around a fixed point or fulcrum (van Deursen 2006)

The figure below represents a typical simple lever. A force on one side of the fulcrum has to be matched by a force on the other side to create equilibrium.
There are three distinct forms of lever, the formation of which depends on the relative position of the fulcrum to the resistance and force. The form of the lever usually changes relative to function.

1\textsuperscript{st} Order Lever - the fulcrum lies between the force and the resistance (eg see-saw).

2\textsuperscript{nd} Order Lever - the resistance lies between the fulcrum and the force (eg Wheelbarrow). Often used to make work easier

3\textsuperscript{rd} Order Lever - the force lies between the fulcrum and the resistance. – smaller distance and velocity required for larger faster movements (eg biceps insertion)
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**BODY (COG), AND CENTRE OF PRESSURE (COP)**

The *COG of the body* is the point about which the mass of all body segments is evenly distributed. In the anatomical position it is thought to be at the level of the second sacral vertebra, inside the pelvis. However the COG will shift as limbs move relative to the body. eg if both arms are elevated to a horizontal position, the COG moves forward and upward relative to its location in the anatomical position.

The *centre of pressure* is the point of application of the ground reaction force. This force reflects Newton’s third law, the law of action/reaction in that the force exerted by the body onto the ground is reflected back at the centre of pressure. Usually, during quiet standing, the ground reaction force and gravity pulling on the COG will be similar but this is not necessarily the case during movements.

**BASE OF SUPPORT**

Every object, unless it is floating in space, has to rest on a supporting surface. The surface area of the part which is involved in support of the object, inanimate or a human body, is known as the *base of support* (BOS).

**BALANCE, EQUILIBRIUM AND STABILITY**

These terms are often interchanged in their use but they are all slightly different.

If the line of gravity is within the base of support then the body is said to be in *balance*.

When all the resultant forces and moments acting on a body are equal to zero then *equilibrium* is said to occur. If the body is stationary when all the forces add up to zero then the body is said to be in *static equilibrium*. If the body moves with a constant linear velocity it is said to be in *dynamic equilibrium*. If, after a displacement by a force of short duration, the body tends to return to its original starting position then it is said to be *stable*.

The following equations should jog your memory about *Power*. If you can’t remember the explanation behind these equations you should revise from a basic text book such as Trew and Everett, Human Movement.

**POWER**

For linear motion

\[
\text{Power} = \text{Force} \times \frac{\text{distance}}{\text{time}}
\]

[or ] \[
\text{Power} = \text{Force} \times \text{velocity}
\]

For rotational motion

\[
\text{Power} = \text{Moment} \times \frac{\text{angular displacement}}{\text{time}}
\]

[or ] \[
\text{Power} = \text{Moment} \times \text{angular velocity}
\]
MUSCLE WORK

If the muscle force and the distance between muscle origin and insertion are known:

\[ \text{Work} = \text{Muscle force} \times \text{muscle length change} \]

If the net joint moment and joint rotations are known:

\[ \text{Work} = \text{Net joint moment} \times \text{joint angular displacement} \]

During a concentric contraction the muscle force and the muscle length change are in the same direction. The above equation will then result in a positive outcome and therefore results in positive work. During an eccentric contraction the muscle force and the muscle length change are in the opposite direction. The above equation will then result in a negative outcome and therefore results in negative work. During an isometric contraction there is no length change of the muscle and therefore, in biomechanical terms, there is no work done.

MUSCLE POWER

If the muscle force and the distance between muscle origin and insertion are known:

\[ \text{Power} = \text{Force} \times \text{velocity of contraction} \]

If the net joint moment and joint rotations are known:

\[ \text{Power} = \text{Net joint moment} \times \text{joint angular velocity} \]

During concentric contractions, power is generated (positive power). During eccentric contractions, power is absorbed (negative power).
The static mechanoreceptors in the knee are found in the capsule, intra-articular and collateral ligaments and menisci. They consist of Type I & II receptors (Pacinian and Ruffini nerve endings), type III, (Golgi Tendon Organs: GTO) and type IV (pain receptors). Table 1 summarizes their location, type and role.

### RECEPTORS IN STATIC STRUCTURES

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Afferent fibre</th>
<th>Threshold</th>
<th>Adaptation</th>
<th>Role</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruffini</td>
<td>Group 2</td>
<td>Low</td>
<td>Slow</td>
<td>Joint position sense, Intra-articular pressure changes</td>
<td>Capsule and ligaments (predominantly flexor aspect of joints)</td>
</tr>
<tr>
<td>Type I</td>
<td>Myelinated</td>
<td></td>
<td>(tonic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rapidly conducting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacinian</td>
<td>Group 2</td>
<td>Low</td>
<td>Fast</td>
<td>Kinaesthesia, including acceleration/deceleration at end range</td>
<td>Capsule, ligaments, periosteum</td>
</tr>
<tr>
<td>Type II</td>
<td>Myelinated</td>
<td></td>
<td>(phasic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rapidly conducting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Golgi tendon-type</td>
<td>Thinly myelinated</td>
<td>High</td>
<td>Slow</td>
<td>Protective response via inhibition of agonist at extremes of joint range</td>
<td>Ligaments, near attachments</td>
</tr>
<tr>
<td>receptors</td>
<td>Medium conducting</td>
<td></td>
<td>(tonic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free nerve endings</td>
<td>Unmyelinated</td>
<td>High</td>
<td>Non-adapting</td>
<td>Pain related to abnormal stress or chemical response</td>
<td>Articular cartilage, ligaments</td>
</tr>
<tr>
<td>Type IV</td>
<td>Slow conducting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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Ruffini nerve endings are Type I mechanoreceptors which are low threshold and therefore easily stimulated by changes in ligament or capsular tension or pressure changes within the knee. Their slow adapting properties allow them to produce continuous activity in response to variation in capsule or ligament tension, providing information relative to posture alignment. The Ruffini nerve endings are thus more adapted to contribute to JPS. They are found predominantly in the flexion side of joints and respond to stress in the collagen tissues in which they lie.

GTO’s, found in the capsule and ligaments, are Type III tension specific mechanoreceptors which are high threshold and thus tend only to be stimulated at extremes of ranges and produce an inhibitory response to the agonist motor neurone. They therefore provide a protective mechanism during positions that increase the risk of injury in the knee and are conversely quiescent when the joint is held in one position for long periods.

Pacinian nerve endings are Type II mechanoreceptors which are thickly encapsulated and cone-shaped. They are low threshold receptors and are therefore easily stimulated. However, they are also fast adapting and so tend to produce an on/off response to a continuous stimulus. Because they will adapt rapidly to changes in tension in the ligament, they are better suited to providing kinaesthetic sensation, especially acceleration or deceleration at the beginning and end of knee movement. Increased firing of these receptors would provide the central nervous system (CNS) with an indication of the speed of joint movement.

Free nerve endings are widely distributed in ligaments, joint capsule and the peripheral region of the menisci. The afferent neurones are Type IV which are unmyelinated and slow conducting. They do not adapt to continuous or repeated stimulus and will therefore continue to fire. They comprise the nociceptive system and are stimulated by changes in mechanical stress placed on the tissues in the knee or by a change in chemical composition of the surrounding tissue. The abnormal or excessive mechanical deformation is more likely to occur at the extremes of joint range suggesting that function is more likely to be a protective one in potentially injurious situations. The stimulation by chemical change would explain the pain felt following effusion or haemarthrosis associated with injury.
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DYNAMIC RECEPTORS

The table below outlines the mechanoreceptors found in dynamic tissues

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Afferent fibre</th>
<th>Threshold</th>
<th>Adaptation</th>
<th>Role</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle Spindle</td>
<td></td>
<td></td>
<td></td>
<td>Information about muscle length changes</td>
<td>Intrafusal muscle fibres in parallel to skeletal muscle</td>
</tr>
<tr>
<td>Type Ia</td>
<td>Both myelinated, fast -conducting</td>
<td>Low</td>
<td>Fast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type II</td>
<td></td>
<td>Medium</td>
<td>Slow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Golgi Tendon Organ</td>
<td>Myelinated, fast -conducting</td>
<td>Low for active stretch/ Higher for passive stretch</td>
<td>Slow</td>
<td>Protective mechanism against excess force in a muscle.</td>
<td>Mainly musculo-tendinous junction, also in tendon substance. In series with skeletal muscle</td>
</tr>
</tbody>
</table>

Muscle spindles are mechanoreceptors found within intrafusal muscle fibres, which run parallel to the extrafusal fibres in skeletal muscle. They are found in almost all skeletal muscle and vary in density, with proximal muscles having the highest density and distal muscles the lowest. Intrafusal muscle fibres do not contribute to the contraction force of a muscle but modify the tension within the capsule enclosing the intrafusal fibres and their associated afferent mechanoreceptors.

Muscle spindles are mainly classified into two types: nuclear bag and nuclear chain fibres, although there are a number of variations.

Both fibres types have an afferent supply of Type I (primary) and Type II (secondary) neurones. The Type Ia afferents are found in both bag and chain spindle fibres and spiral around the mid section of the intrafusal region. These afferents are low threshold and respond to small stretches for short periods. The Type II afferents, however, are mainly found in the chain fibres, although they can be found in some bag fibres. They synapse directly onto the intrafusal spindle fibres rather than the spiral configuration of the Type I afferents. These Type II afferents have a
higher threshold for stimulation by stretch but continue to fire during a prolonged stretch. They also recover rapidly after stretching in preparation for repeated stimulation.

These intrafusal muscle fibres are supplied by two types of motor nerves. Gamma motorneurones are the smallest type of motor nerve and only supply intrafusal muscle fibres. Medium sized beta afferents supply both intrafusal and extrafusal fibres (Enoka 2002). Efferent stimulation of the spindle complex produces a fast contraction in the chain fibres and a slow contraction in the bag fibres (Gandevia et al. 1992). Stimulation of the intrafusal fibres via these motorneurones increases the tension on the afferent receptors which will increase their sensitivity to stretch. Thus the sensitivity of the muscle spindles and hence the reflex stimulation of extrafusal muscle fibres can be modified by the CNS.

Muscle spindles provide information on changes in muscle length. The magnitude of the receptor response can provide an indication of the rate of change of muscle length whereas the difference between agonist and antagonist intrafusal afferent activity can provide an estimation of the effort involved in a specific movement. Muscle length changes occur more obviously in the mid-range of joint movement and therefore the spindle afferent information appears to be used more in this part of the movement range than at extremes.

Golgi tendon organs (GTO) are mainly found at the myotendinous junction but also in the tendon and the muscle belly, in series with extrafusal fibres. They are purely sensory receptors with only an afferent supply, in contrast to muscle spindles. which also have an efferent supply. These afferent nerves are Type Ib and are myelinated and fast conducting but are slow adapting. Consequently, their firing tends to stay fairly constant during muscle contraction. Their response is minimal in relaxed muscle, either in a static position or if it is being slowly lengthened passively through normal range. This suggests that GTO might provide more input to joint position sense in active, rather than passive movements in contrast to muscle spindle activity.

**LEVELS OF MOTOR CONTROL**

**SPINAL - REFLEX**

Spinal level reflexes are usually monosynaptic and provide rapid automatic reactions in response to joint stress, although it is now thought that even these motor responses can be conditioned Latash (1998). Via this mechanism, muscle spindles and GTO influence muscle control by adjusting lower motorneurone activity in response to small
stretches. Reaction times for this type of response are thought to be in the region of 60ms (Schmidt and Wrisberg 2004)

Can you think of 3 examples of spinal level reflexes?

Can you think of 3 examples of brain stem level reflexes?

**BRAIN STEM – TRIGGERED RESPONSE**

Processing at the brain stem is still too rapid to be considered a voluntary movement but allows slightly more time for minor modification. Latency for this type of response is around 80ms. Again information from musculotendinous receptors contribute to other afferent information from joint receptors comprising the internal feedback system. In addition, the exteroceptors from vestibular and visual afferents provide information regarding the external environment during a movement and vision can also assist proprioception when limbs are in view.
Synapses in the higher centres including the motor cortex, basal ganglia and cerebellum are able to control the most flexible type of automated response available but also have the slowest response time of around 180ms. Cognitive awareness of limb position, movement and sense of effort are all processed at this level via interneurones synapsing with the receptors previously mentioned. The joint receptors are thought to be predominantly mediated from these higher centres (Cordo et al. 1994).

Can you think of 3 examples of higher centre level reflexes?
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Suggested Reading


Browenstein B 1997 in Browenstein B, Shaw B (Eds). Functional movement in orthopaedic and sports physical therapy : evaluation, treatment and outcomes. Edinburgh: Churchill Livingstone (Chapters 1, 3 & 7 most useful)


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LEARNING OUTCOMES RELATIVE TO IFSP COMPETENCIES

The following learning outcomes have been mapped against the IFSP competency document. This will help you complete your ACPSM CPD portfolio, showing evidence of learning in these areas.

LEARNING OUTCOMES

At the end of the course the physiotherapist should be able to:

EXERCISE

1. analyse the effects of sport-specific exercise and training on human anatomy, exercise physiology, biomechanics, and movement science in different sporting contexts [IFSP competency 1A.1]
2. analyse the specific sports skills and sequences required by an athlete and develop appropriate field tests to estimate the athlete’s response in different sporting contexts [IFSP competency 1B.1]
3. develop and perform sport-specific functional tests to assess the athlete’s potential risk of injury in different sporting contexts [IFSP competency 1C.4]
4. use advanced knowledge of normal movement patterns and typical injury mechanisms to interpret the additional demands placed on the body in different sporting contexts [IFSP competency 1D.1]
5. make individual and sport-specific professional judgments regarding injury risks in different sporting contexts – integrating the following information:
   • physical and psychological performance capacity,
   • the difference between load and ‘loadability’,
   • the influence of other factors such as pain and injury history, age, pre-existing or co-existing conditions, and functional limitations,
   • requirements of the specific sport or exercise, including the potential for overtraining injuries,
   • potential impacts of environments and equipment, and
   • ethical issues and awareness of a duty of care to the athlete [IFSP competency 1D.2]
6. develop appropriate intervention strategies to reduce the athlete’s risk of injury in different sporting contexts, such as:
   • physical conditioning, strengthening and endurance training,
   • factors affecting muscle control,
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- appropriate muscle stretching,
- training to facilitate the development of greater efficiency in movement [IFSP competency 1E.2]

7. provide effective training and education in injury-prevention strategies during training for sport and exercise participants of all levels and abilities. [IFSP competency 1E.3]

8. design and implement evidence-based conditioning, strengthening and stretching exercise programmes, specifically related to an individual, an injury, and a sporting role [IFSP competency 3E.2]

9. design and implement individualised and evidence-based programmes to increase neuromuscular control, incorporating skill acquisition principles (for example, static, dynamic, reactive or preparatory techniques). [IFSP competency 3E.3]

10. collect relevant subjective and physical data to assess the individual’s ability to participate in physical activity and exercise, identifying potential risks [IFSP competency 5C.1]

11. estimate safe and optimal progression of participation in different types of activity, integrating knowledge about the individual with consideration of exercise training principle [IFSP competency 5D.2]

12. monitor an individual’s participation, obtain feedback on motivation and adherence, and modify advice if required [IFSP competency 5F.1]

REHABILITATION

1. identify the potential impacts of various factors on recovery, including:
   - co-existing and pre-existing conditions,
   - the experience of acute or chronic pain,
   - the effects of other medical interventions on different body systems, and
   - the impact of complications on recovery
   - psychological, social and cultural influences [IFSP competency 3A.3]

2. identify clinical and performance-related assessment techniques and protocols that are most appropriate in different sporting contexts [IFSP competency 3A.5]

3. identify current intervention strategies used to promote early safe return to activity and progression to optimal function, including risks associated with their use [IFSP competency 3A.7]
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4. observe and analyse specific sporting movements required by the athlete on return to participation *in different sporting contexts*, including
   - activities associated with the original injury,
   - movements specific to a team role or position
   - movement/energy demands of a specific sporting activity

5. discuss issues relating to compliance with advice and intervention strategies, including factors affecting motivation and adherence, and different coping strategies [IFSP competency 1A.11]

6. select and apply the most appropriate clinical and performance-related tests to the individual, the injury, and the sport, *in different sporting contexts* (for example, tests of strength, functional performance, range of motion and flexibility) [IFSP competency 3C.5]

7. analyse the results of clinical and performance-related tests relative to sport-specific expectations [IFSP competency 3D.1]

8. integrate rehabilitation goals with foundational knowledge to devise an individual, research-based, sport-specific programme of intervention strategies [IFSP competency 3D.4]

9. make professional judgements regarding the appropriate times for progression of participation following illness or injury *in different sporting contexts* [IFSP competency 3D.6]

10. modify the use of clinical and performance-related testing to provide the most appropriate information at different stages in the rehabilitation process (for example, progressing from tests of functional movements to complex field testing that relates directly to the sporting demands) [IFSP competency 3F.1]

11. incorporate awareness of the principles of measurement reliability and validity into judgements relating to the interpretation of assessment data [IFSP competency 3F.2]

12. make appropriate use of intervention outcomes:
   - as biofeedback for the athlete and other professionals
   - to encourage compliance
   - to inform advice regarding participation and progression of training, and
   - to influence team decisions [IFSP competency 3F.3]

13. sensitively communicate with the athlete to promote compliance with advice and rehabilitation, incorporating exercise psychology principles such as goal-setting, pacing and feedback [IFSP competency 3E.7]

14. sensitively advise the athlete and other professionals regarding progress and appropriate timing of return to sporting and exercise activities [IFSP competency 3E.10]

15. sensitively educate the athlete and other individuals regarding principles of post-injury rehabilitation and prevention of re-injury to the athlete and other individuals [IFSP competency 3E.11]