PHYSICAL TRAINING TO IMPROVE SKYDIVING PERFORMANCE

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A Thesis for the Australian Parachute Federation

TITLE: Physical training to improve skydiving performance.

AIM: For all formation skydiving athletes to maximise their potential in training and competition through improved physical preparation and injury management.

OBJECTIVES:

to give an understanding of the physical demands placed on our body whilst performing formation skydiving events.

to provide a background of relevant physiology to improve understanding of training program.

to identify and develop the physical components for a training program specific to the formation skydiving event.

to propose an ideal and varied training program.

to outline injury prevention strategies and injury management protocol.

to encourage thorough physical preparation to enhance your training and competitive performance in events.

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INTRODUCTION

Performance excellence on the day of competition is what all athletes strive to achieve. Hence preparation/training for the event is essential. The higher the level of competition the more time, energy and other resources is likely to be injected into the preparation. Resources are finite and hence training has to be efficient and effective at improving our physical performance. As the competitive standard in formation skydiving disciplines continually breaks known boundaries, individuals and teams are training harder, for longer and with greater intensity than previously before. Training no longer singularly incorporates just skydiving skills, it must also include the development of your physical aptitude to better your aerial performance.

The purpose of this paper is to outline the physical requirements or components that are utilised in the sport of formation skydiving, ie the energy systems utilised, flexibility and strength requirements, and hence on the basis of this information, propose a varied training schedule to develop these areas. Training will reduce the risk of injury by preparing your body for the demands of the sport. I will outline the strategies for injury prevention and management should injury occur.

As is evident in Australia the number of competitors increases considerably every year, along with the standard in both open and intermediate fields. Training will not only raise your competitive edge by improving your physical aptitude to your chosen sport but it will help in the prevention of injury which generally only occurs in when the demands of the activity exceed the capabilities of your body.

The more our sport grows the more professional it will become, externally with increased media attention and internally as the competitive members of our sport grow and the standard increases, the more our athletic status will be recognised.

We take it for granted or assume that all national and international competitors train intensely for their chosen field. For example iron man Grant Kenny doesn't just turn up on the day and compete successfully nor do Mal Meninga or Keiron Perkins achieve their success without intense preparation.

Training can be broken down into two categories:

specific skill/event training. The equivalent to us is doing training jumps, or Mal game training or Keiron swimming,

component training. By identifying the physical requirements of your sport and working on them individually to enhance your overall performance. For example Mal doing sprint training and lower body weights to enhance leg strength and power and develop anaerobic energy production systems, ball handling exercises to improve passing, catching, eye hand coordination etc. Keiron working on aerobic fitness to improve speed and endurance in the water and upper body weights to improve strength.

This is a very basic analysis of a training system and I am trying to demonstrate that in comparison to other sports and athletes our preparation as skydivers for formation skydiving events could be improved upon. We need to take ourselves seriously, view ourselves as athletes, respect ourselves as much as we respect the dedication of our individual sports heroes.

Simply component training will improve our performance as will skill practice and it is at present an area overlooked by the majority of skydivers in preparation for their chosen event.

At the end of this paper you should have an understanding of the physical requirements of formation skydiving and training principles, have a varied training program to work on and be able to manage any injuries sustained whilst training and competing.

Firstly we need to analyse the physical demands of the activity in question. The training we do needs to directly benefit the physical requirements of formation skydiving. We need to isolate the important components of the activity and replicate it in training with respect to energy systems used, muscle groups, time frame of the activity and intensity.

Energy demands

The skydiving training day is of approximately 8 hours duration, with many short, high intensity bursts of activity. Approximately 6 skydives with a minimum of 2 creeper sessions each, so 18 episodes of high intensity work of no more than 2 minutes, with continuous low intensity activity ie packing, walking, engineering, exit practice etch, in between.

The high intensity components require training of the anaerobic energy systems but an aerobic base is essential to maintain the activity throughout the day.

Flexibility & strength requirements

The skydiving body position is unique in that it is foreign to our usual work and comfort positions. Our lifestyle involves mostly flexion type activities eg sitting, bending over work benches etch compared to the skydiving position of extension. In freefall and on the creepers we arch in a horizontal (prone) position. Our neck, spine, shoulder and hip joints are all in an end of range position, extended as far back as possible. This places considerable strain on our ligaments and joint structures. Being in this end of range position our muscles are also disadvantaged. The muscles contracting or doing the work are working against the effects of gravity and are fully shortened or contracted. In this state they have past their optimal position to generate strength hence they are weaker and more vunerable to injury. Our muscles and joints function optimally with least risk of injury in mid range of movement. Hence we have to adapt to the required body position.

Our neck, spine, shoulder and hip joints must be comfortable in an extended position, in addition our neck, spinal, shoulder, chest,hip and thigh muscle groups must be supple enough to allow this position to be functional.

Our shoulder, neck, spinal and hip muscle groups must be trained to work (produce strength) in this shortened position at high intensity bursts of no more than 2 minutes.

A summary of an extended training program is shown below.

Fitness and Conditioning for Formation Skydiving

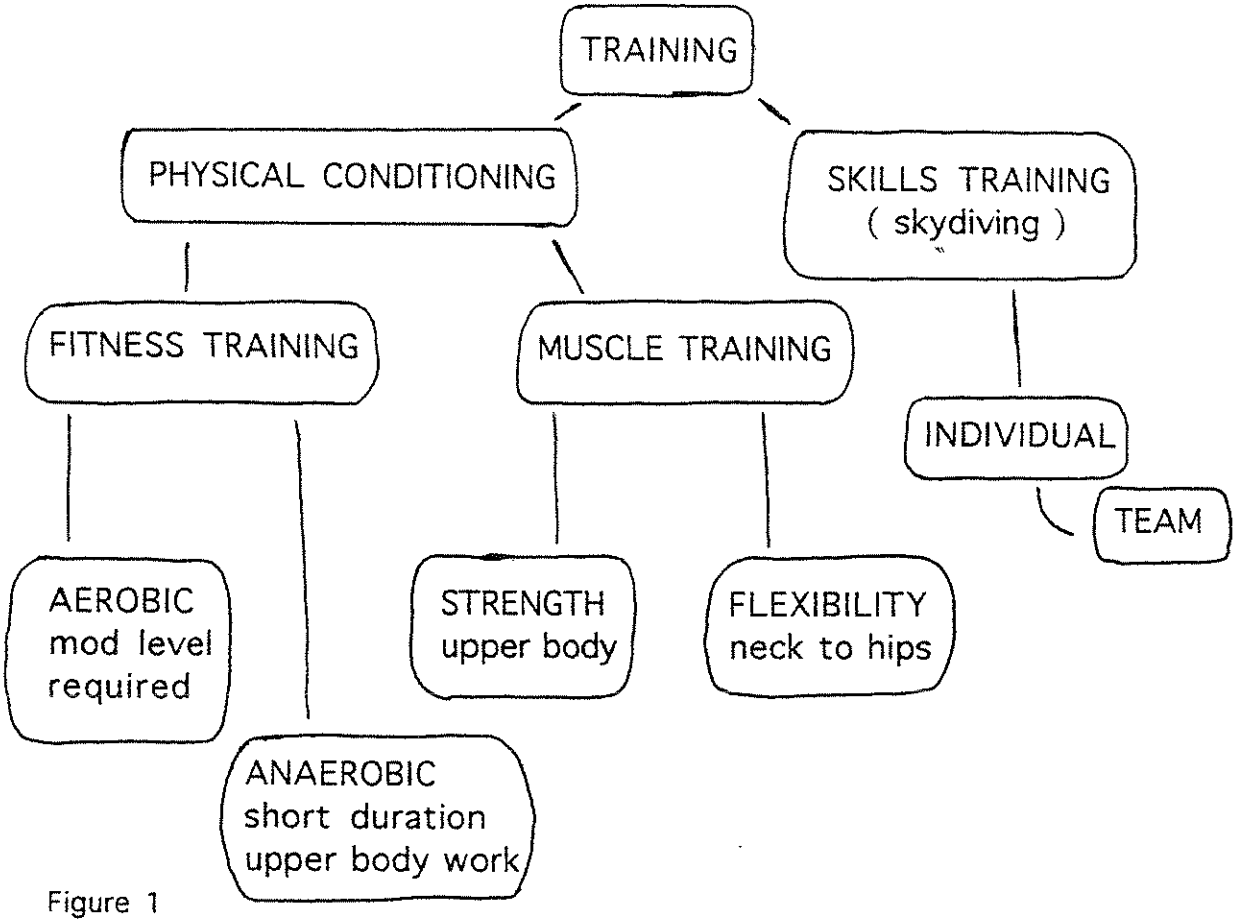


Figure 1

Development of a training program should be based on the demands of the sport. The athlete must be aware of the sport's major physical conditioning and skill requirements.

Muscle function

Movement is the result of forces generated by the interaction of certain proteins and is fuelled by chemical energy (Vander 1980: 211). Muscle cells have a specialised ability to generate force and motion.

Muscle Types

There are three types of muscle: skeletal, smooth and cardiac. Skeletal muscle is attached to bones via tendons and its contraction is responsible for movement of the skeleton. Muscle contraction is controlled by the somatic nervous system and is under voluntary control. Smooth muscle, found in the walls of some internal organs, is under control of the autonomic nervous system and therefore not under your conscious control. Cardiac muscle is the muscle of the heart and its contraction propels blood through the body. It is also under control of the autonomic nervous system.

Skeletal muscle

Skeletal muscle consists of bundles of fibres held together by connective tissue.

A single muscle cell is known as a muscle fibre and is cylindrical in shape.

Within each fibre are a number of independent cylindrical elements known as myofibrils. These continue the length of the muscle fibre.

The myofibrils consist of smaller filaments which are arranged in a repeating pattern, known as a sarcomere, along the length of the fibril.

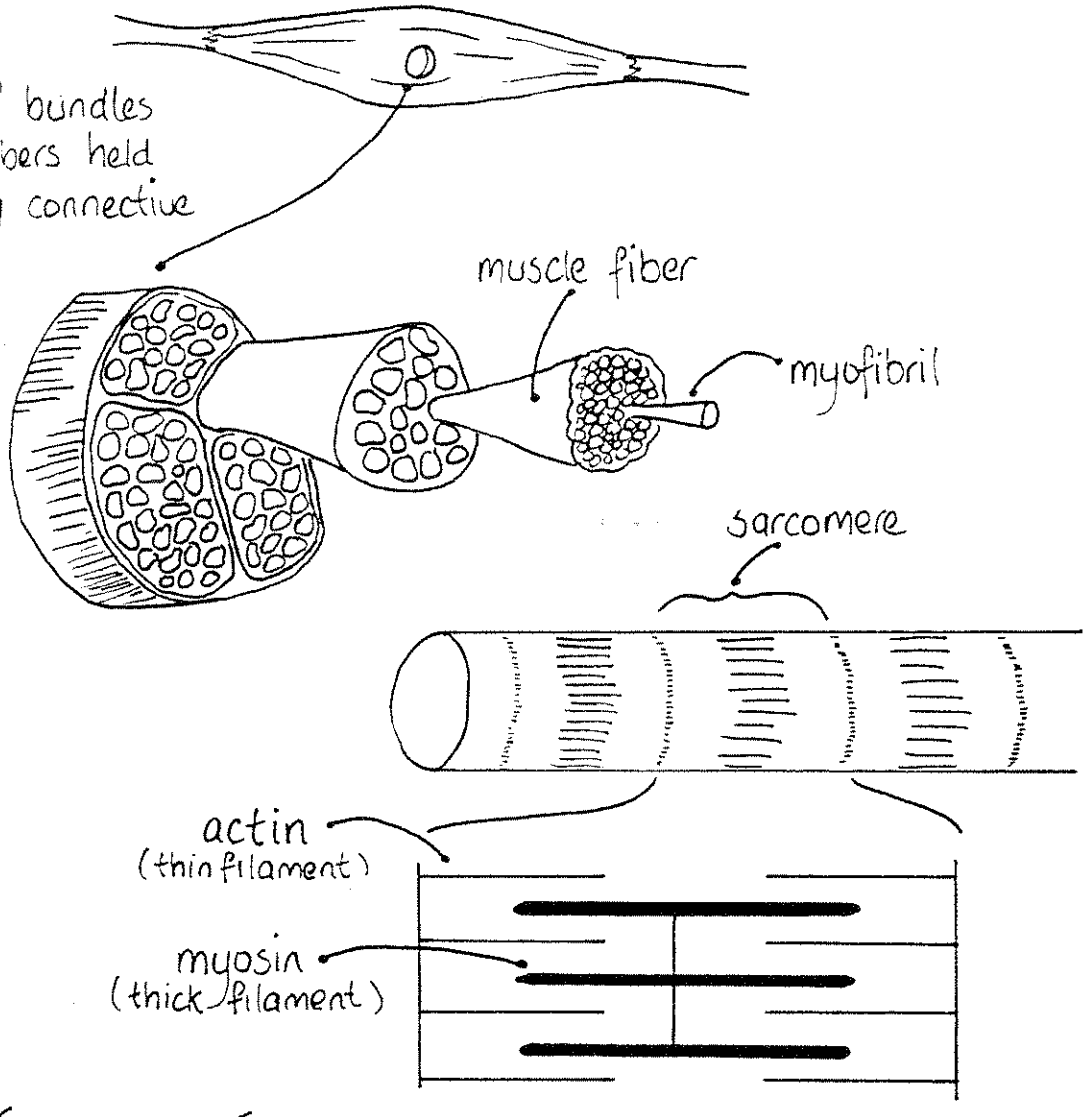
The sarcomere is the basic contractile unit.
Each sarcomere is made up of two types of contractile proteins: myosin (thick filaments) and actin (thin filaments). See figure 2.

Each muscle fibre is connected to a motor neuron (a nerve that carries electrical impulses or messages) via an axon process bringing the muscle under the control of the central nervous system.
There is a very critical dependence of the muscle fibre on its motor neuron not only to provide stimulation for contraction but also for its

SKELETAL MUSCLE

figure 2

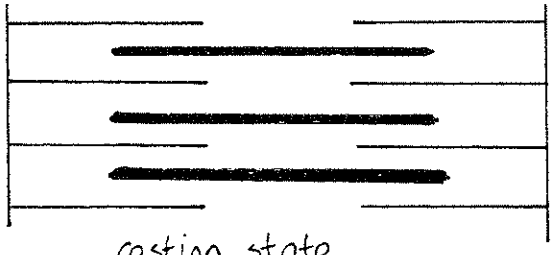
made up of bundles of muscle fibers held together by connective tissue



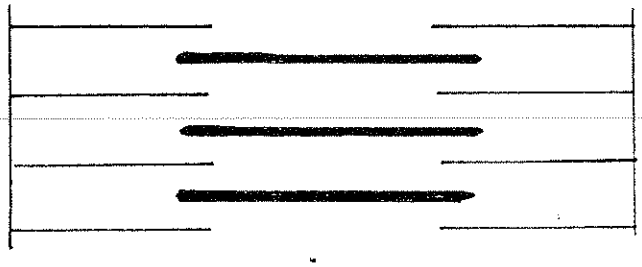
SLIDING FILAMENT THEORY

figure 3

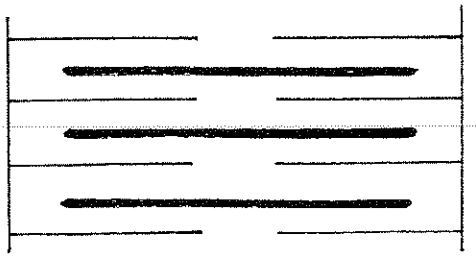
no change in filament length - but sarcomere length will change.



resting state



lengthening



shortening

continued survival and development. An increase in the amount of neural activity, or exercise, may produce a considerable increase in the size of the muscle fibres called hypertrophy. In contrast a decrease in neural activity will reduce muscle mass called atrophy. A reduction in muscle mass through injury or lack of activity is known as disuse atrophy and will start to occur within 48 hours post injury and secondly when the nerve fibres are severed or destroyed, called denervation atrophy, the muscle suffers the same fate with minimal hope of ever returning to normal function.

Mechanism of contraction
Sliding filament theory

This is the proposition that explains how protein filaments within the sarcomere move to cause muscle fibre contraction.
The sarcomere shortens in length with no change in the length of the actin and myosin filaments.

Simply the actin and myosin filaments within each sarcomere during contraction and relaxation slide past each other (fig 3), retaining their individual lengths but reducing the length of the sarcomere.

Cross bridges extending from the surface of the thick filaments make contact with the adjacent thin filaments (fig 4). On activation, the cross bridge acts like an oar of a boat pulling the thin filament past the thick towards the centre of the sarcomere. One stroke of a cross bridge produces only a small displacement of a thin filament relative to a thick, but the cross bridges under go many cycles during a single contraction.

Energy in the form of ATP performs two distinctive roles in the cross bridge cycle; firstly the energy released from the splitting of the ATP molecule provides energy for cross bridge movement and secondly ATP binds to myosin breaking the link between actin and myosin at the end of the cross bridge cycle. Rigor mortis directly results from the loss of ATP in the dead muscles. Without ATP the myosin cross bridges are able to bind to the actin but the bond between them is not broken. The thick and thin filaments become cross linked to each other producing the rigid condition in the dead muscle. In contrast, in the living muscle at rest the myosin bridges are not bound to actin and the filaments slide readily past each other when the muscle is passively stretched.

CROSSBRIDGE ACTION

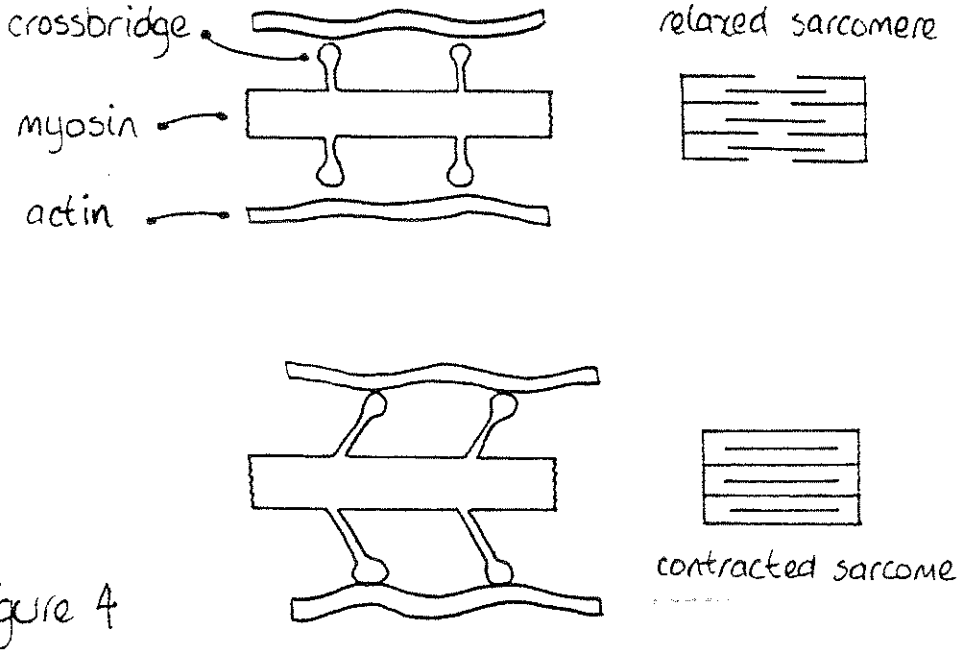


figure 4

LENGTH ~ TENSION RELATIONSHIP

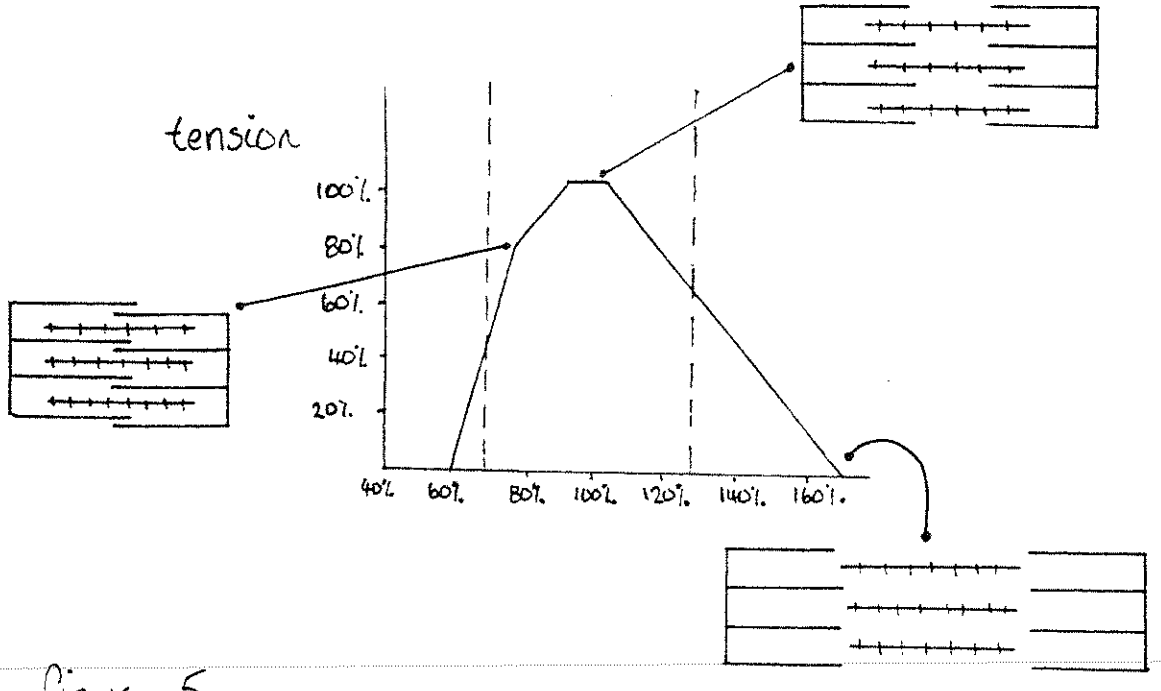


figure 5

Contraction refers to the active process of generating force within a muscle. This force, generated by the sliding filaments in the presence of ATP, is exerted parallel to the muscle fibre. The force exerted by a contracting muscle on an object is known as tension, and the force exerted on on the muscle by the object is the load, therefore they are opposing forces.
When a muscle changes length and moves a load, the muscle contraction is said to be isotonic (constant tension). Isotonic training consists of both concentric and eccentric contractions, ie lifting a weight is concentric as the muscle shortens whilst developing tension and lowering a weight is eccentric as the muscle lengthens whilst developing tension. In contrast when a muscle develops tension but does not change length, the contraction is said to be isometric (constant length).

Length - tension relationship

The relationship between a muscle's length and the tension it develops is an important one. A muscle fibre can be passively stretched to various lengths and the maximal tension on stimulation can be measured. There is an optimal length at which the muscle produces the greatest tension. When the muscle length is shortened to 60% or lengthened to 175% of the optimal length it develops no tension. In the shortened position extreme overlap of the filaments restricts further shortening and in the lengthened position there is no overlap between the filaments hence the cross bridges are ineffective (fig 5). The muscle can develop tension within this range. In the body the relaxed length of the muscle is very nearly the optimal length for force generation. The total range of of length changes a skeletal muscle can undergo is limited to about 30% increase or decrease of its resting length and is often much less.

Therefore the length - tension relationship affects the amount of force a muscle is able to develop in varying joint positions. This is significant as whilst skydiving our extensors are functioning in an extremely shortened position hence they are less able to develop as much tension.

Flexion of a limb is bending of a joint and extension is straightening. These actions require two separate muscles, one to cause flexion (a flexor eg biceps) and another for extension (an extensor eg triceps). (See figure 6). Groups or pairs of muscles which produce oppositely directed movements of a limb are called antagonists. They have to work together, ie when biceps contracts to flex or bend the elbow triceps must relax to allow the elbow to flex. In this case the biceps is called the agonist (prime mover) and triceps the antagonist.

ENERGY SYSTEMS

Energy systems determine our capacity to perform work or exercise. Training should incorporate the use of the appropriate energy system. If the energy system we require to perform maximally is inadequate fatigue results and hence our performance is affected.

The role of ATP (adenosine triphosphate)

The functioning of a cell depends on its ability to extract and use the chemical potential energy locked within the structure of the organic molecules.

Energy is released on the breakdown of ATP and used to perform work by the cell ie muscle contraction, transport of molecules across cell membranes and the synthesis of new molecules etc.

Total stored ATP can supply the cell's energy requirements for only a fraction of a second. Storage of energy within the body is in the form of glycogen, carbohydrates, fats and proteins. We need our energy systems to continue to provide ATP for further activity.

Muscle Action

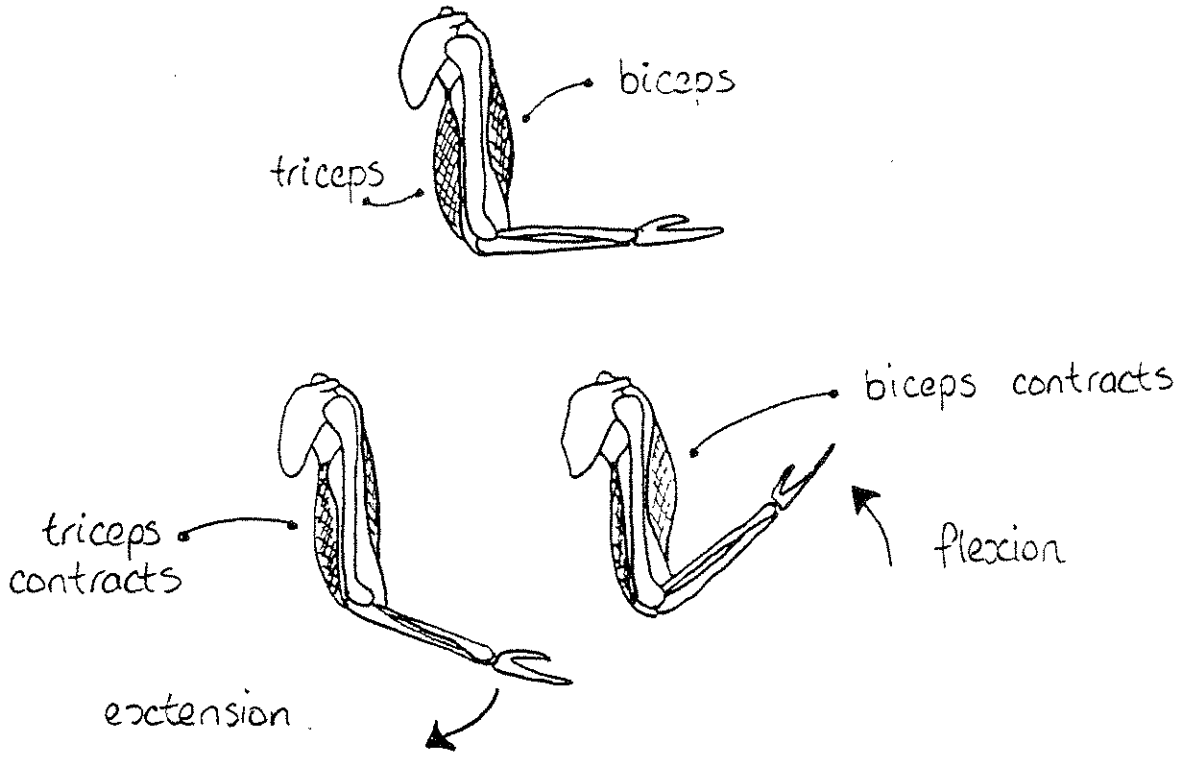


figure 6

There are three main processes by which energy is produced to be used at a cellular level.

The first two occur in the absence of oxygen and are hence called anaerobic systems and are responsible for short bursts of activity up to 2 minutes.

The third process occurs in the presence of oxygen and is called the aerobic system. This system enables us to keep producing energy for extended periods of time eg a marathon.

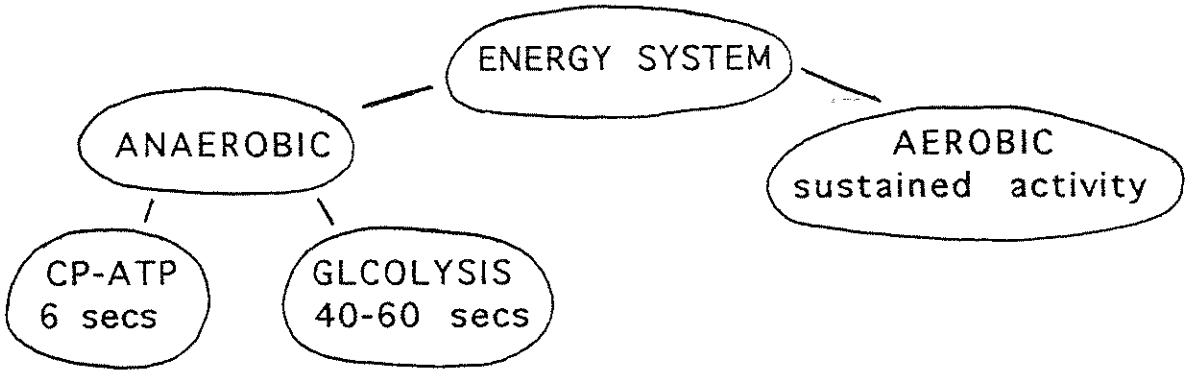


Figure 7. Energy Systems

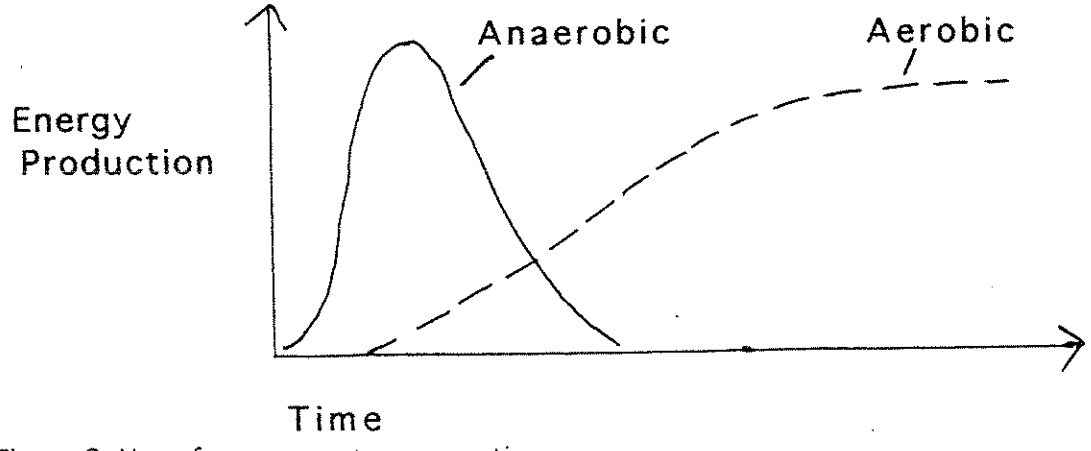


Figure 8. Use of energy systems over time.

Anaerobic power is the maximal ability of the anaerobic systems to produce energy.

Aerobic power is the maximal amount of oxygen that can be consumed per minute during maximal exercise - measured as VO2 max.

Creatine phosphate system (anaerobic)

Molecules of CP (creatine phosphate) are stored in the cell and are broken down to form ATP which is in turn broken down upon which energy is released.
It is the availability of CP that limits short term heavy exercise.
Exclusive use of the ATP - CP system is only possible in high intensity activities that last less than 6 seconds, eg single tennis swing or a discus throw.
Energy sources are quickly rebuilt - 50% of energy is available 30 seconds later and it is completely restored within 2 - 3 minutes.

Glycolysis (anaerobic)

When a maximal effort is continued beyond the CP system, energy is provided from the glycogen stored in the muscles. This process is called Glycolysis. In this process glucose (called glycogen in its stored form) is broken down within the cell to produce ATP.
Glucose found in the blood (at varying levels) and in its stored form glycogen is used as fuel for this process.

Glycolysis can produce large quantities of ATP in the absence of O2 but it requires a large quantity of glucose molecules to produce a relatively small amount of ATP eg 1 mol of glucose for 2 ATP mols.
In the breakdown of glucose to ATP a waste product is produced lactic acid. A build up of lactic acid in the muscle will impede its ability to continue to produce ATP.
An exercise that requires maximal use of the lactic acid system can last no longer than 40 - 60 seconds.
Continuous use beyond 60 secs will lead to lactic acid accumulation which can take up to 1 hour to be cleared in the unfit muscle, this compromises the muscle's ability to continue to produce energy.

Aerobic (oxidative phosphorylation)

This is the process by which oxygen is used to release ATP from available fuel sources ie glycogen, carbohydrates, fats and proteins, producing only CO2 and H2O as waste products.
Compared to the 2 molecules of ATP produced in glycolysis, 36 molecules of ATP are produced from a single glucose molecule

The CP system produces ATP immediately until the stored CP runs out, approximately 6 - 10 seconds.

Glycolysis kicks in to produce ATP but its not very efficient, producing only 2 ATP molecules from 1 molecule of glucose and a large quantity of waste product lactic acid relative to the energy that has been released.

The aerobic process enables a wider fuel source to be used, it is efficient producing 36 ATP from 1 glucose molecule and it is able to be sustained, it just takes more time to get going.

Fatigue

The production of energy can be retarded in two major ways:

- # inadequate fuel supply ie glucose, CP, O2 etc
- # build up of waste products

If the rate of ATP breakdown exceeds the rate at which ATP can be formed, contractile responses become weaker ie muscle performance decreases resulting in fatigue.
If a muscle is to maintain its contractile activity, ATP must be produced as rapidly as it is broken down.

Your body's ability to do this is an indication of your fitness or training specific to your activity.

By including appropriate energy system requirements into your training routine you will:

- # Increase stores of glycogen in the muscle and liver
- # Increase stores of CP
- # Improve delivery of O2 to the cells and be able to maintain this ie cardiovascular fitness.
- # Increase the rate of breakdown, maintaining an optimal environment in which to work ie preventing waste products from accumulating.
- # Enhances the cell's chemical efficiency ie improve energy transfer systems within the muscle, between the blood and liver, and releasing energy stores (Sperryn 1983).

Specifically lactic acid will impede energy metabolism. It begins to accumulate in the muscle when the body is unable to clear it as fast as it is being produced. To clear it, it is moved to the blood, taken to the liver where it is broken down.

The onset of blood lactate accumulation is higher in the trained state, hence performance would begin to suffer at a much later point.

The end result of your body's inability to cope with exercise requirements is FATIGUE ..... defined as the inability to continue to exercise at the same intensity.

Principles of training

Training programs should be planned. Goals set for both short and long term and progress continually monitored. Each session should consist of three parts, a warmup, training period and cool down.

Once the components to be trained have been identified, attention can be turned to how these components can be changed. Training theory incorporates the **principle of specificity** meaning that the individual components that make up the activity need to be trained. Physical fitness for improved sport performance involves exercise modes and physiological changes very specific to the sport in question (Vander 1980).
The aim of training is to maximise physiological adaption to the demands of that event. The main determinants of training are the **type and intensity** of work undertaken (Sperryn 1983). In addition the **overload principle** must be applied to stimulate change. For example the existing physical components need to be stressed beyond that which is normal or usual. To be optimally effective overload must be applied with **progressive resistance**. As training progresses your body adapts to these new demands, ie becomes stronger, therefore the demands need to be increased so that the system continues to be overloaded. At some point the desired physical state will be achieved and a **maintenance** plan in which the load conditions or the stimulus to the system, will remain stable (Noble 1986).

Training and Injury prevention

The purpose of training is ultimately to enhance performance, in addition it is a successful injury prevention strategy. By adapting your body to cope with the demands of skydiving you are reducing the risk of injury.

A training program is designed to overload your existing physical state hence there is a certain potential for injury in all training programs.

The program optimally needs to overload the athlete to a point to stimulate change but not to create injury. If it produces a high incidence of injury or its intensity is so stressful that participants drop out because of lack of enjoyment, it may prove to be counterproductive (Noble 1986: 297). In a study by Pollock (1973) to

study the effects of exercise duration (15, 30, and 45 minutes for 3 days per week for 20 weeks). The other group exercised at various frequencies (1, 3, and 5 days per week for 20 weeks). Injuries were highest among 5 day per week exercisers and the 45 minute duration exercisers. The data supports the prescriptive recommendation of 30 minutes, 3 days per week for those seeking health benefits from exercise. Injury and drop out rates are also significantly higher in interval training (higher intensity, short burst) programs compared to continuous training (Pollock et al 1972).

COMPONENTS OF TRAINING AND INJURY PREVENTION

Energy systems

Energy systems determine our capacity to perform work or exercise. Training should incorporate the use of the appropriate energy system. If the energy system we require to perform maximally is inadequate fatigue results and hence our performance is affected.

The three main processes by which energy is produced are the anaerobic, CP and glycolysis, and aerobic systems are physiologically different but act in concert together with one predominating in any given activity. See figure 8.

Anaerobic fitness is the ability to provide fuel for short burst, high intensity activity and to be able to replenish energy stores to a maximum level in a minimum time period.
Cardio - respiratory fitness or endurance is the ability of the body's circulatory system to supply oxygen to the muscle and convert this oxygen to energy for movement.

A single skydive and final creeper session is about 60 seconds so the major source of energy is from the anaerobic system. Hence in training you need to simulate this time frame of activity ie high intensity, short duration work (less than 2 minutes). The anaerobic system then becomes efficient at supplying this energy for the duration of the activity and replenishing the intracellular fuel sources in between jumps to a maximum level.

A lengthy training day involves not only jumping but continuous, low intensity work such as packing, engineering, dirt diving, creeping, exit practice, debriefing etc. It is therefore just as important to be able to sustain your energy and enthusiasm from beginning to end hence a moderate to high level of cardiovascular or aerobic fitness is vital, ie low intensity, long duration work.

Aerobic - Anaerobic training

There are obvious differences between strength and aerobic - anaerobic training but there are similarities as well. Muscle hypertrophy change is the emphasis in strength training and cardio-respiratory / metabolic change is the focus of aerobic - anaerobic training. Training might be described on a continuum that considers both the energy system involvement and the physical dimensions of the training. On the anaerobic / strength end of the continuum, training is marked by high resistance, low repetitions and shorter duration exercise. The aerobic / muscular end is more low resistance, high repetitions and longer duration exercise (Noble 1986).

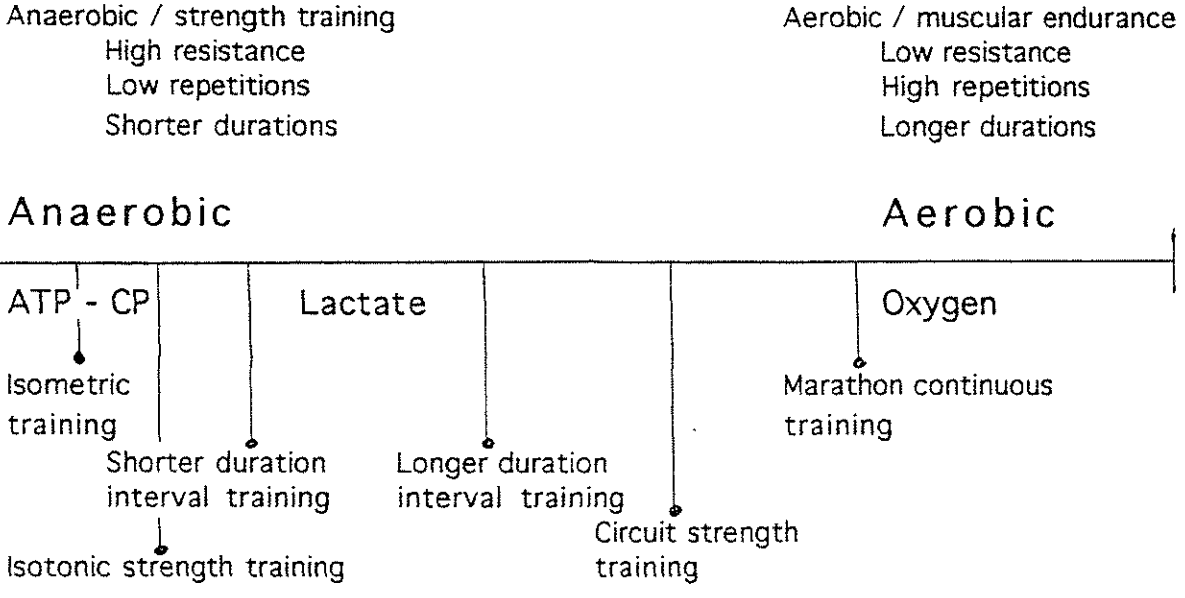


Fig 9. Training Continuum (Noble 1986)

Continuous training is sub maximal by nature and the more completely the activity can be labelled aerobic the more suitable this type of training will be. However this type of training will not improve anaerobic requirements.
Prior to World War II, training for the mile run was distance training only. Changes in world records of this event, began with Roger Bannister's breaking the 4 minute barrier. This was largely the result of interval, ie anaerobic, training methods.

Interval training uses intervals of high intensity activity less than the time frame of the real event with rest periods in between. The rest periods allow a more intense workout and provide a time frame for replenishing fuel sources. See figure 10.

Strength training

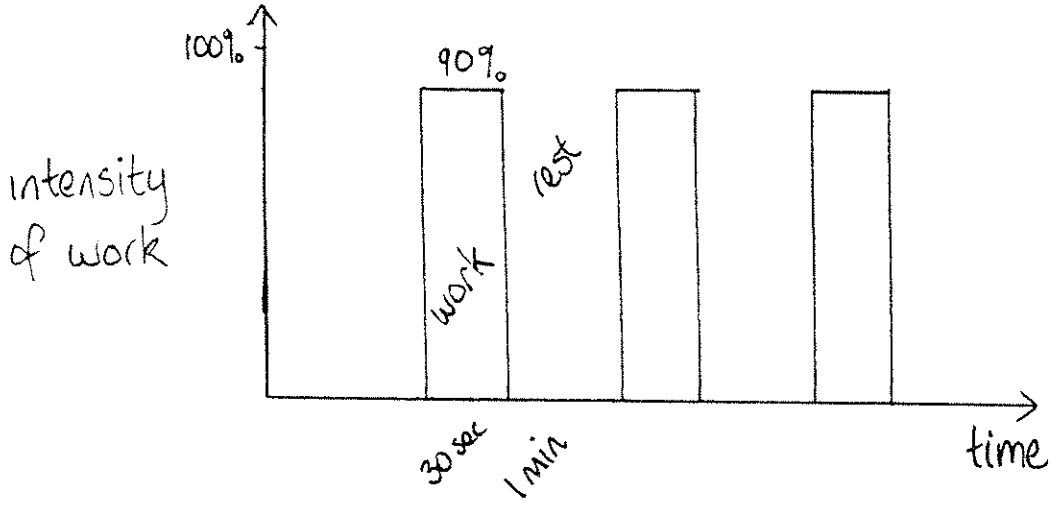
The muscle groups used need to be strong enough to cope with the work required, perform repeatedly without fatigue and protect the joints from injury from extreme range of movements.
When planning your strength training you must simulate the joint position and workload used when skydiving (specificity of training). When considering your skydiving body position, all your important joints, (neck, back, shoulders and hips), are all in an extreme position called end of range. Simply meaning the joints are at the end of their range of movement. This position must be simulated as much as possible in your weight training.

If your muscles aren't used to performing work in end of range positions, they will not be able to generate as much force as if the joint was in a middle of range position. So essentially they are weaker, they will fatigue more easily so they are unable to do the work required, hence performance will be affected and they are less able to protect the joint and hence are more at risk of injury.

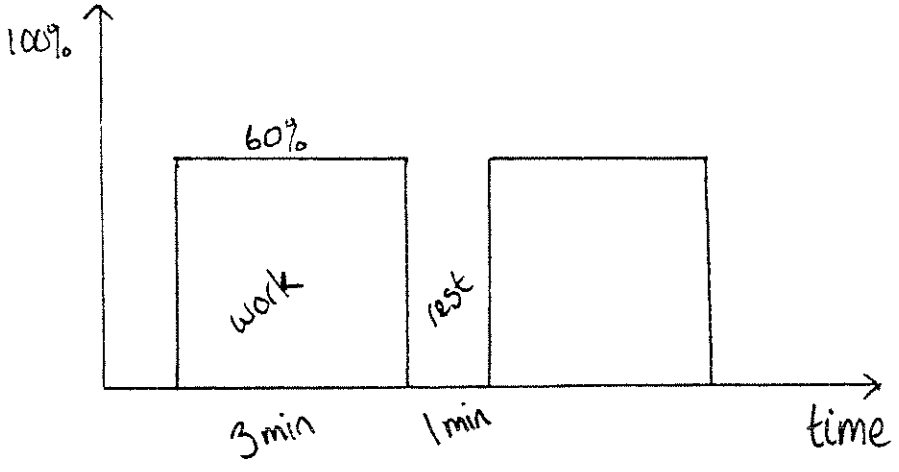
By strengthening your muscles in this position in training you will improve their performance and reduce the risk of injury.

INTERVAL TRAINING

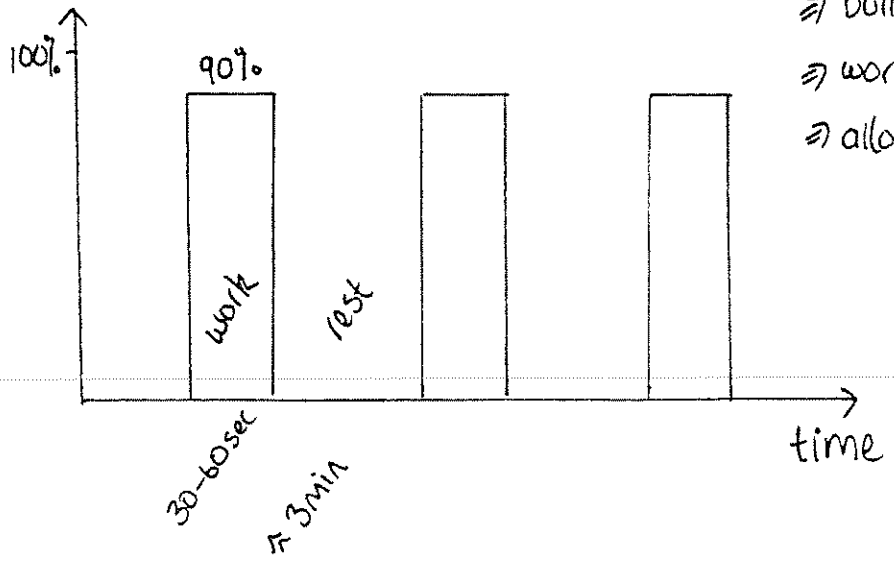
short duration interval training



long duration interval training



skydiving: interval training schedule



- build work intensity to 90%
- work period 30-60 sec
- allow generous rest time

figure 10

There are a variety of methods to develop strength.

Isotonic training consists of both concentric (muscle shortening) and eccentric (muscle lengthening) contractions eg lifting a weight is concentric and lowering a weight is eccentric.

De Lorme and Watkins (1948) found that strength would increase if resistance and repetitions were manipulated in 3 sets of 10 repetitions. The resistance is gauged at 10 RM (repeated maximum) meaning the amount of weight that can be lifted a maximum of 10 times. Further study has shown the stimulus for strength gain using isotonic training seems to require a 3 set program with the RM requirement at the minimum, 3 and the maximum 10. This is the optimal range and further stimulus does not produce further gains.

Anderson and Kearney (1982) compared three training regimes: high resistance - low repetition, medium resistance - medium repetitions, low resistance - high repetitions. Their results support training specificity for strength and endurance but note that if either component is selected for training, the other untrained component receives some benefits.

Isometric training involves the dynamic contraction of a muscle resulting in no change in muscle length or movement of the skeleton (Noble 1986:538). Hence strength gains only occur at at the isolated joint angle with no carry over to other positions. It is not a very popular method of training.

Circuit strength training is the development of a strength program to develop aerobic power in addition to strength. Resistance is reduced to allow repeated contractions and aerobic activity fills in the rest periods. Emphasis on lower resistance and moderate repetitions promotes aerobic power and adding running to the rest periods further enhances this.
This training method produces significant strength and aerobic changes but are lower with respect to more specific training.

Isokinetic training involves the development of maximal tension through range of movement at a constant speed. This requires special equipment and is often costly and inaccessible to most . The big advantage of isokinetic training is to replicate the speed of motion of the activity in training. Studies in this area suggest that isokinetic

training is specific to velocity, hence athletes should train at velocities closer to the athletic requirement.

Ideally isokinetic training with true equipment is the most effective way to train, studies show it is more effective at producing strength than isotonic methods and produces less muscle soreness. Isokinetic and isometric methods are both equally effective at improving strength gains but isokinetic equipment is often inaccessible and isometrics are specific to joint position so as training methods are limited in their application. Isotonic training is probably the best option to most people.

Flexibility

Flexibility simply ensures that your muscles and joints are comfortable with the range of movement that is required. If you have poor flexibility, ie stiff joints and are only just able to achieve an adequate range of movement, you are likely to strain and injure the ligaments, muscles and surrounding soft tissue by asking them to do more than they are capable of.
Hence stretching forms the basis of your training program and is paramount in your injury prevention strategy.

Flexibility training

A daily stretching routine is essential. By stretching we are attempting to adapt our body to a new state, hence we must stretch regularly to improve and then maintain this supple state.
There are three stretching techniques.

Static stretching. This involves the gradual lengthening of a muscle to the point of stretch. Hold for 10 - 30 seconds. A feeling of mild tension should subside during the stretch.

PNF stretching (proprioceptive neuromuscular facilitation). This is a form of static stretching incorporating an isometric contraction of the muscle being stretched or the antagonist. Contract the muscle in the lengthened position, holding for 5 seconds, releasing and continue the stretch.

Ballistic stretching. Often called dynamic stretching involves bouncing or vigorous movement at the point of stretch. It is not recommended because it can result in significant injury.

Stretching

Stretching means forcing the body to break out of its old patterns and extend it range of motion. Breaking patterns of any kind tends to be uncomfortable, its painful and strenuous at first, but the more you do it, the better you get. Stress and cumulative injury take away your flexibility, stretching gets it back.

Skydiving places your body in unfamiliar positions and demands high intensity work in these positions. Stretching will enable you to work comfortably in prone and extend yourself eg increasing fall rate or reaching for a grip with less chance of injury. Because it helps minimise muscle stress and increase recovery speed, stretching lets you take on longer harder training sessions and get stronger faster.

Benefits of stretching

Stretching exercises can improve flexibility thereby enhancing performance and decreasing the chance of injury. Regular stretching will achieve the following changes.

reduced muscle tension
enhanced circulation
increased muscle and tendon length
increased range of motion and suppleness

When you stretch the sheaths (fascia) covering the muscle lengthen and loosen. Connective tissue within the joints is a major factor in limiting motion. All soft tissue, including scar tissue responds to consistent stretching.

Your stretching program should be approximately 30 mins. Stretching daily will be more effective in maintaining and improving your flexibility goals.

Stretch in a comfortable location free from cold drafts and distractions. This is also a good time for mental relaxation and a laugh with your team mates before the more intense part of the training day starts. Wear loose fitting clothes. Have a daily leader of the stretching routine. This creates variety and gives everyone an opportunity to choose the routine they prefer.

Give yourself several months to start and progress gently. If you are too aggressive your joints can develop too much slack and not enough power, which may leave you susceptible to joint subluxation or dislocation.

Warmup

A cold body is a tight body so first get warm. Light activity such as jogging, jumping jacks etc for about 5 minutes, enough to break into a light sweat. This will increase blood circulation and muscle temperature and hence make your stretching more comfortable and more effective.

Stretching technique

To stretch a muscle you must first take it to the end of range of movement at this point (the point of stretch) you will start to feel some discomfort (not pain), hold here for 20 seconds, release the stretch and repeat 3 times. Each time the point of stretch may be in a more lengthened position, even as you hold the stretch the tightness may ease so gently add more pressure to the point of discomfort again. By stretching you are asking your body to adapt to a new range of motion so the holds are important, they give the muscle and surrounding soft tissue time to adapt. The repetition reinforces the new position and daily frequency maintains and adds to it.

It will take time to develop your technique so be patient remember this is a new skill.

Be careful working on the muscle and soft tissue at the end of range. Never bounce or be too aggressive at this point or injury will most certainly result.

To further develop your technique you can include **contract relax** or PNF methods. At the point of stretch isometrically contract the muscle being stretched for 5 seconds then relax taking the muscle to the point of stretch again. Repeat 3 times. The theory is that after a maximal contraction you get a maximal relaxation. Stretching a relaxed muscle is far more effective as often resting muscle tension restricts full stretch.

Another method is to take the muscle to the point of stretch and this time isometrically contract the antagonist ie if you are stretching your quadriceps, at the point of stretch you would isometrically contract the hamstrings and hold for 5 seconds. release and resume the stretch. Repeat 3 times. By stimulating the antagonist you will get an immediate relaxation of the agonist ie the muscle you are stretching. Both these methods also develop athletic flexibility meaning you have the muscle power to move in and out of these stretched positions easily.

Work through your stretches in a logical order, ie start with your head and neck muscles moving down to finish with leg and ankle muscles.

Basic stretching guidelines

* **Warm up** before you start stretching

* **Don't bounce** at the point of stretch

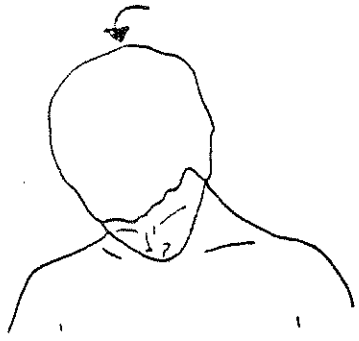
* **Breathe** slowly, deeply and easily. Unnatural breathing is a sign of over stretching

* **Don't overstretch**

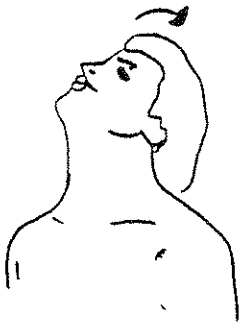
* **Hold** a stretch in a comfortable position. Tension should subside as you hold

* **Concentrate** on an area being stretched, so that if an increase in tension is felt it can be relieved

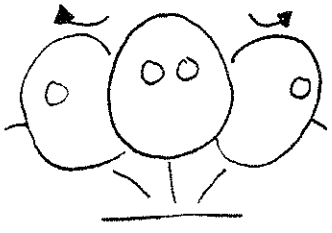
* **Stretch regularly**



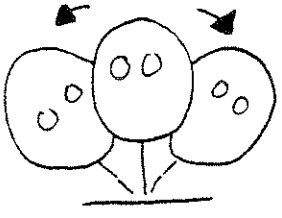
1. neck flexion
forward, to the right, to the left



2. neck extension
place hand behind neck for comfort



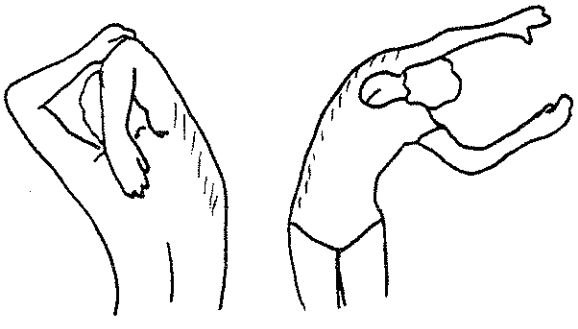
3. neck rotation
look over shoulder
allowing back to arch



4. side flexion

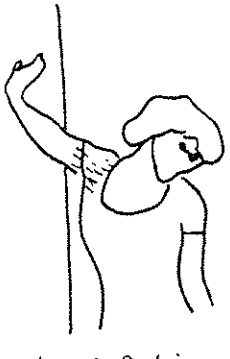
* use gentle assistance with hand to increase stretch

5. triceps stretch

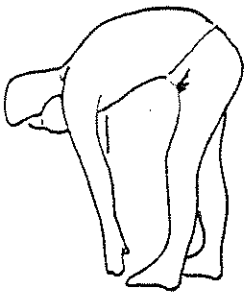


6. latissimus dorsi stretch

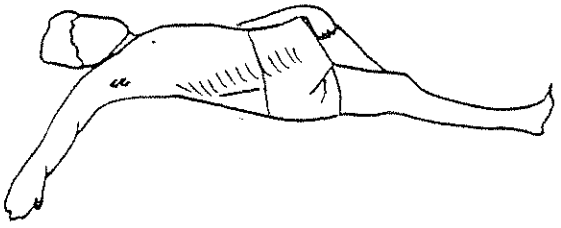
7. rotator cuff &
shoulder extensors



8. chest & biceps

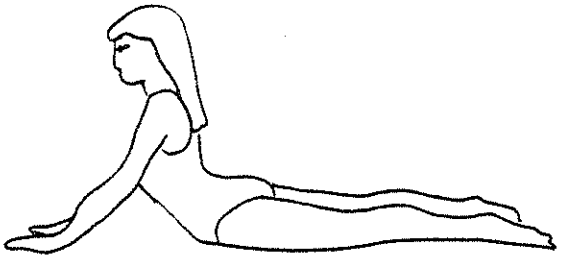


9. lower back



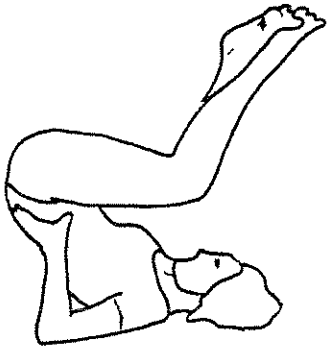
10. low back & buttock

11. buttock

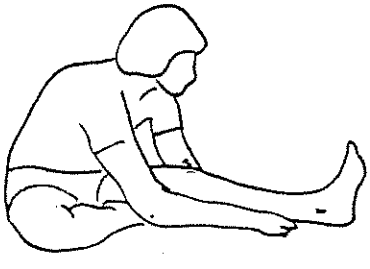


12. back extension

13. chest & upper back stretch

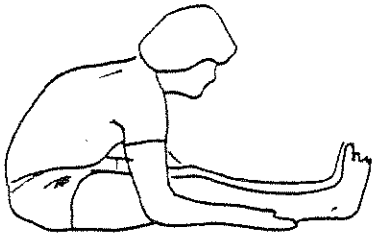


14. spinal stretch & abdominal strength

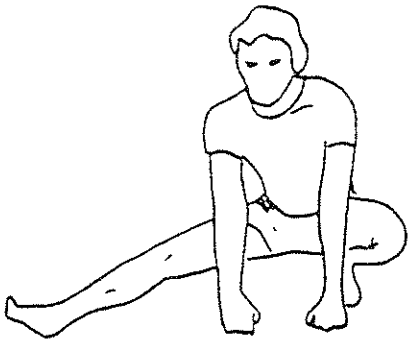


15. hamstring & low back

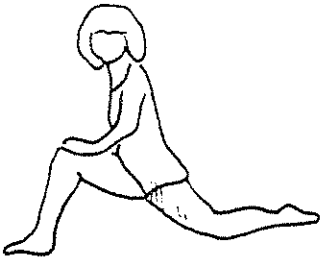
16. groin stretch



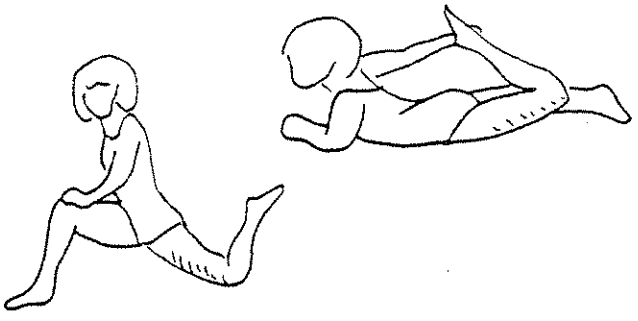
17. back stretch



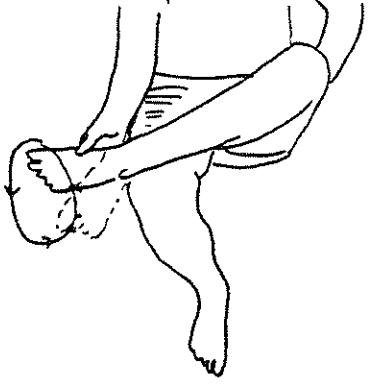
18. groin stretch



19. hip flexor stretch



20. quads stretch



21. ankle circles

This list of stretches is a guide. Please add or adapt stretches to suit your individual needs.

Strengthening

The best way to develop specific strength gains is to commence weight training in a gym. Choose one that is convenient, with knowledgeable and helpful staff, good equipment and value for money.
There are other cross training methods that also develop strength which I will mention later but none as specific as weight training.

By improving your strength in the joint position and range of movement required for skydiving you will be able to perform better for longer with less chance of injury or subject to the effects of fatigue. Your body will be more able to cope with the demands of the sport.

With strength training the muscle will increase in size called hypertrophy. Whilst the number of muscle fibres doesn't change, each will increase in size. Each motor unit becomes more effective at recruiting muscle fibres, in fact early strength gains are attributed to the fact that more muscle fibres are called upon to work. Within each fibre there are changes to improve the efficiency of metabolism hence further adapt the muscle to its new workload.

As the muscle's strength increases it performs a very important injury prevention role. In addition to moving a joint, strength also serves a protective function. As a joint is taken close to or beyond its comfortable range of movement, the muscles surrounding that joint contract to limit further movement hence protecting the joint from injury. If they are weak due to fatigue or unused to developing strength at an end of range position they will be unable to protect the joint and injury will result.

Strength gains take time be patient. Don't do too much initially or you will burn yourself out, in addition don't lift too heavy a weight, build up slowly or you risk injury which will set you back further.

Caution

When weight training you need to allow a 48 hour recovery period. By overloading the muscle microscopic injury occurs, this is the stimulus for change. So you need to allow time for repair.

Your plan

There are 2 schedules that may suit your requirements the first is to attend the gym 3 times per week working on the whole body each time or you may choose to go 5-6 times per week working half your routine at a time. It means each visit is shorter but you go more often. When planning your schedule don't aim to do too much, it will become monotonous and lose its enjoyment and you wont continue your program.

Be realistic with what you can achieve.

Once your program is mapped out keep a record of repetition, load and frequency of attendance. Records are important and are an objective measure of any strength gains. Consistent improvement will motivate you where as failure to progress may highlight poor technique or low attendance.

Strengthening technique

Warm up first, approximately 5 minutes inducing a light sweat.
You should do 3 sets of 8-10 RM of each exercise. Remember an RM is the repeated maximum times you can lift that weight, for intense 10 RM means with x kilos you can repeat the exercise only 10 times before fatigue limits you. If you can lift it 15 or more times you need to increase the load. Hence the RM should determine the weight you choose to lift.

Initially for the first 2 weeks keep the load down until you are familiar with the exercises and any muscle soreness has eased. On completion of each training session a cool down is essential to reduce any post training soreness.

As mentioned previously specificity is vital. When developing your program you need to train all the significant muscle groups involved in your performance and you need to train them in and/or close to the joint position in which they will be utilised in the air. It is not easy to perform all weight training in freefall related positions and whilst there is some carry over at least one out of three (eg triceps) exercises should be in a freefall position.

weight: 10 RM * unless stated otherwise
repetition: 3 SETS OF 10
frequency: 3 TIMES / WEEK

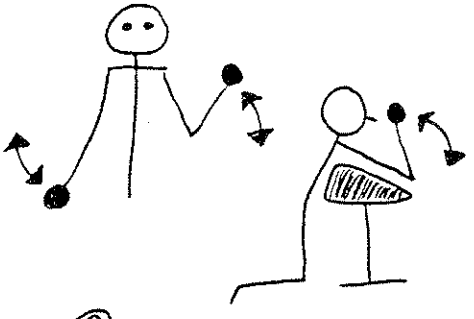
symbols: standing 
sitting
supine
prone

front view 
side view
rear view

BICEPS CURLS

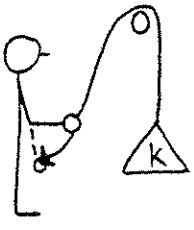
* single either  or  .

* double over biceps bench
(use dumbbell or bar)

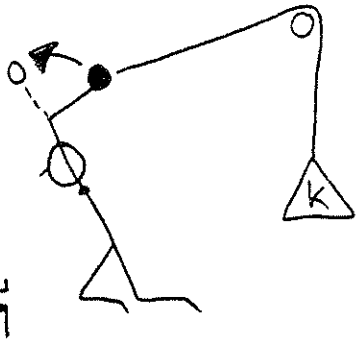


TRICEPS CURLS

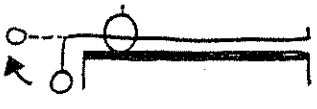
* triceps pull down
(pulley)



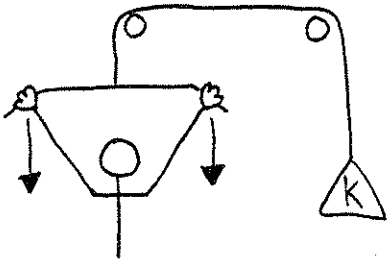
* triceps over head
(free weight or pulleys)



* supine behind head

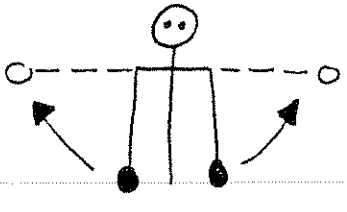


LAT PULL DOWN
BEHIND HEAD (BACK)

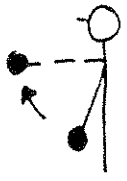


LAT PULL DOWN
TO CHEST (BACK)

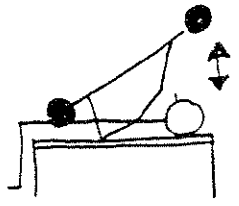
LATERAL RAISE
(SHOULDER)



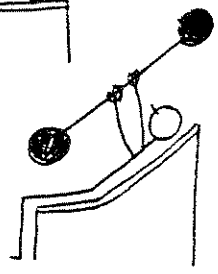
FORWARD RAISE
(SHOULDER)



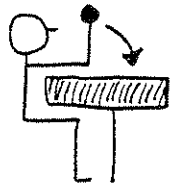
BENCH PRESS
(CHEST AND SHOULDER)



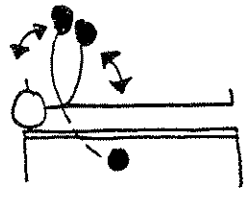
INCLINED BENCH PRESS
(CHEST & SHOULDER)



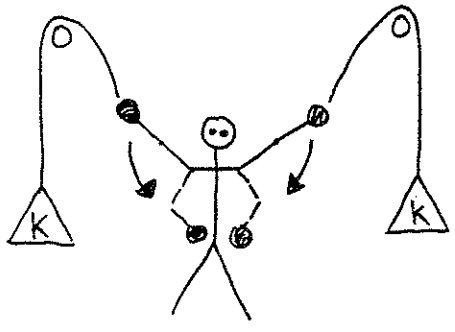
ROTATOR CUFF
(SHOULDER)
Support elbow lower palm to table
& raise rotating only at the shoulder.
This is good for the weak or injured shoulder



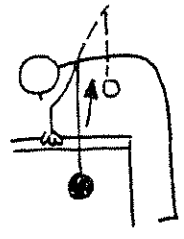
SUPINE FLYS
(CHEST)



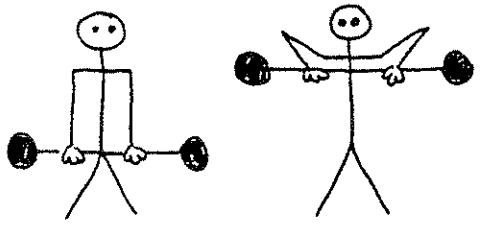
STANDING FLYS
USE 2 PULLEYS (CHEST)



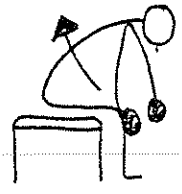
SINGLE ROW
(UPPER BACK)
bending forward over bench



UPRIGHT ROWS
(UPPER BACK)

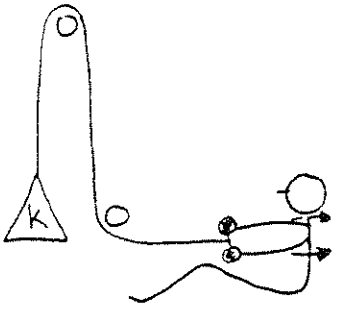


SEATED FLYS
(UPPER BACK & SHOULDER)
bending forward raising arms behind

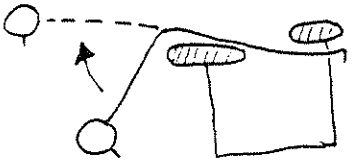


The strengthening program

SEATED ROW
(UPPER BACK)
use rowing equipment



BACK EXTENSION
(LOW BACK & BUTTOCK)
3 sets 30 reps (30 RM)

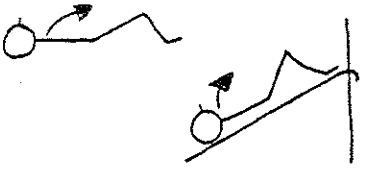


ABDOMINAL CRUNCH
3 sets 30 reps (30 RM)

* supine

* supine on incline

* hanging knee raise



Ask for assistance at your gym when commencing these for the first time to ensure you are performing the exercises correctly.

This is not an exclusive exercise regime there are a variety of weight exercises that will achieve the same thing. I have described the most common ones.

In addition to daily stretching and weekly gym work they are many other activities that develop physical components relevant to skydiving.

We need to develop flexibility in our neck, shoulder, arm, back, hip and leg regions.

Develop strength predominantly in our shoulder, arm, chest and back areas.

Our anaerobic energy systems need training mostly in upper body muscle groups and we need to be aerobically fit to cope with the extended demands of the day.

To develop aerobic fitness there are 4 factors to consider.

 # frequency to gain cardio - vascular fitness you need to exercise a minimum of 3 - 4 times per week. Every second day is ideal.

 # intensity you need to exercise at 60 - 80 % of your maximum heart rate to achieve a training effect. Your maximal heart rate (MHR) is estimated by subtracting your age from 220. The fitter you are the higher the the percentage of your maximal heart rate it is safe to work at.
For instance if you are 40 years old and very unfit then you should work at 60% of your MHR.
If you are working at 80 -85% MHR you are more likely to be working anaerobically and it is unlikely you will be able to sustain this level of exercise for the recommended time. If you are unable to whistle or talk during exercise you are working out at too intense a level.

 # type choose an exercise that works you aerobically eg walking, swimming, cycling etc. The activity must be continuous so minimise any breaks in the activity to get consistency in your work out.

 # time to be effective in your work out sustain your elevated heart rate for a minimum of 15 - 20 minutes. Ideally the workout should be 30 minutes so you can include a warm up and cool down.

Activity	**# benefit and uses**	*** negative points**
swimming	# works your body in a prone (same as freefall position) # predominantly upper body work # 15-30 mins continuous low intensity work for aerobic devt # sprint laps or interval training for anaerobic devt (aim for 30 - 60 second sprint at 70 - 90% intensity with a 2 - 3 minute rest period)	

Activity	# benefit and uses	* negative points
running/cycling	# continuous low intensity work for aerobic devt * uses predominantly leg muscles * promotes low back stiffness and poor flexibility	
skipping	# significant upper body involvement # predominantly aerobic devt * as for running does not promote flexibility	
racket sports	# upper body work and trunk flexibility # eye-hand coordination and reaction time # anaerobic for single hit & aerobic for length of game * uses only one arm	
ball sports	# some upper body work # coordination and reaction time # aerobic devt	
aerobics	# promotes flexibility, coordination & mirror image skills # aerobic devt	
circuit training	# aerobic and strength devt simultaneously # design set to work on predominately on upper body	
surfing	# works body in prone # significant upper body work # anaerobic with bursts of paddling & aerobic with sustained activity	
rowing	# significant upper body work # anaerobic or aerobic depending on work time	
rock climbing	# significant upper body work in position similar to freefall # coordination and balance # left and right involvement # anaerobic activity	

This is not a finite list.

By now you should be able to work out the sort of activities that would benefit skydiving fitness.

Types of injury

There are two types of injury: **acute** and **chronic.**

Acute injuries occur suddenly, often with severe pain

Chronic injuries are either as a result of sustained repetition that places undue stress on a body part or as a persistent re-injury of an acute injury that has not been adequately rehabilitated.

Soft tissue injuries refers to muscle, tendons, ligaments, joints, joint linings, and connective tissue. See figure 11.

The most common injuries to soft tissue include the following:

Strains... occur when the tissue is over stressed beyond its normal range causing fibres to rupture.

Haematomas (bruising)... resulting from a direct blow to the tissue causing internal bleeding and tissue damage.

Tendonitis... occurs when the moving parts become over stressed and inflamed, often due to poor equipment, technique and lack of flexibility.

Common injuries

Neck
pain on neck rotation
= due to a lack of flexibility in extended position

Shoulder
pain on elevation of the arm
= due to weakness of the shoulder extensor muscles (rotator cuff)
= poor upper back and shoulder flexibility

dislocated shoulder
= due to weakened joint structure

Arm
floater's arm... pain from floating exit position
strain on biceps muscle or tendon
= due to weakness and / or repetitive strain

Lower back
pain on extension (arching)
= poor flexibility in low back and hip

Seek advice and management for all significant problems especially before they become major ones.

KNEE JOINT

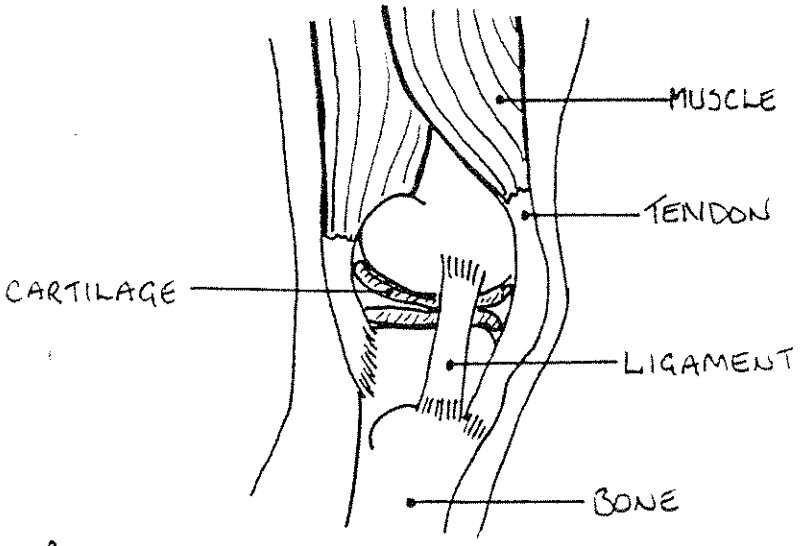


figure 11

RESPONSE TO INJURY

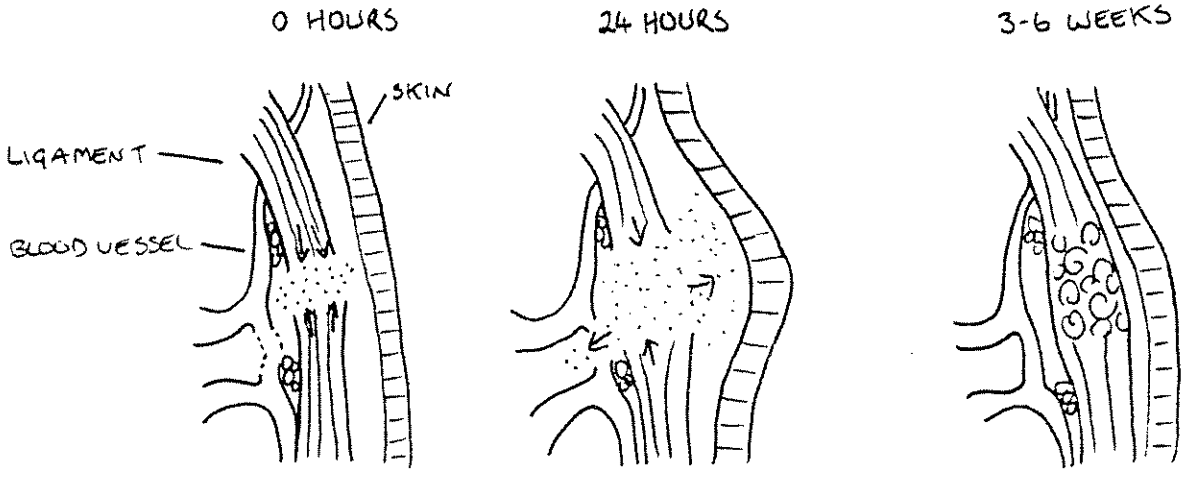


figure 12

* I.C.E. controls bleeding & swelling ⇒ smaller scar and less overall damage

Bodily responses to injury

1. Tissue disruption caused by the injury results in damage to the blood vessels and hence rapid bleeding and swelling.

2. Swelling or accumulated blood restricts the normal flow of fresh blood (carrying oxygen) to the tissue.

3. The lack of oxygen in the area of the injury will cause cells to die, increasing the extent of the injury.

4. The clot may continue to bleed if disrupted, causing extra swelling and pain, which again increases the extent of the injury.

All soft tissue is replaced with scar tissue after an injury. The scar tissue is not as elastic as the soft tissue it is replacing, so flexibility must be regained to restore full function. See figure 12.

INJURY MANAGEMENT

REST

ICE

COMPRESSION

ELEVATION

REFERRAL

Commence R.I.C.E.R. immediately. The quicker you start the more effective it will be.

Rest.....protects the injured part from further injury.

continued activity will risk further strain to the soft tissue and will increase bleeding adding to existing damage.

use pain as a guide to limit your activities, ie if it hurts stop.

Ice.... cooling controls bleeding, swelling and pain.

causes contraction of the local blood vessels hence reducing blood flow in the injured area, the lighter the bleeding, the less swelling occurs and the faster the effusion (collection of blood) disappears.Healing proceeds more rapidly with less scar tissue formed in the injured tissue.

provides local pain relief by controlling bleeding and cooling the local pain fibres, ie the part goes numb providing an anaesthetic.

ice the part for 20-30 mins every 2 hours until bleeding and pain is controlled, checking skin appearance throughout for evidence of an ice burn. Icing is useful for up to **48 hours**.

 # do not apply ice direct to skin.

Compression...controls bleeding and swelling

provides counter pressure to the localised bleeding assisting the body's own methods of stopping blood flow.

cooling and compression should be applied simultaneously.

apply for up to 72 hours.

Elevation.... controls bleeding and swelling

when the injured part is elevated its blood flow is reduced and the expelled blood is transported away more easily.

elevate affected part immediately at least 45 degrees when lying flat.

for extensive bleeding and swelling elevate for up to 72 hours.

Referral.... for accurate diagnosis and management

an accurate diagnosis as early as possible will assist you in managing the injury and hence prevent reoccurrence.

All elements of R I C E R work together.
If only one or two are completed it will not be as effective as when all four parts are used.

Continue R I C E R for 48 - 72 hours following injury.

No alcohol... alcohol dilates (opens) the blood vessels in the peripheral parts of your body. Hence the red nose and warming effects you feel on a cold day. This is exactly the opposite of the aims of R I C E R. In fact alcohol will significantly worsen the injury and if you have enough, will deaden the pain which is your body's only warning indication you are doing more damage.

No heat... again this promotes bleeding and will significantly worsen the injury.

No sauna, spa or massage

Do not attempt to 'run out' swelling and injury

For appropriate management after the 48 hour period I suggest you seek professional advice. One of the most common problems after an injury is reoccurrence. This is rarely due to the severity of the injury but rather due to poor, or lack of, follow up management to return the injured part to 100% working order.

Injury rehabilitation

The aim of rehabilitation is to restore normal function to the injured area. If this is not complete re-injury is probable.

The aims of a rehabilitation program are:

to decrease the initial inflammation

to gradually mobilise, stretch and strengthen the injured area

to maintain the athlete's general body conditioning

It is best to seek professional advice in this area. A physiotherapist will be able to set an ongoing program for you relevant to the demands of your activity and advise you when it is safe to return to sport.

Physical training will improve performance and becomes more important as the intensity of training and competition increases. The components of training are flexibility, strength and fitness. All these must be developed specifically to the demands of the sport of formation skydiving. Variety is important as it maintains interest and will appeal to a wide range of individuals. Compliance is essential, so setting realistic goals is a must.

Injury prevention and management is also an important element. To ensure you are functioning at your maximum throughout training and competition you must be unrestricted by weakness or injury. Manage all injuries properly and thoroughly, seeking advice when necessary.

My suggestions for a training program are as follows:

Flexibility # stretch daily and prior to any physical activity.

Strength # gym work a minimum of three times per week.
work on the upper body.

Fitness # select three aerobic activities per week.
sustain each for a minimum of 20 minutes.

modify some typically aerobic activities by using interval training to constantly vary your routine.

alternative or cross training activities help maintain interest and enthusiasm as well as developing a variety of relevant physical components.

keep these in mind on bad weather weekends or for team building activities.

So get fit for your sport and have fun.

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