

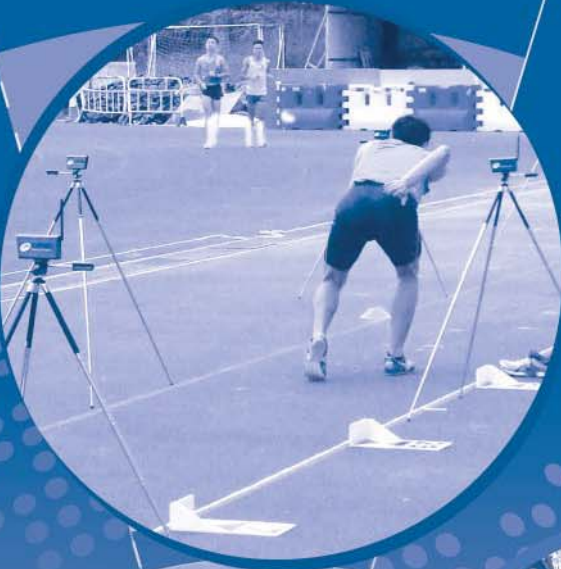


# Handbook of Support Services for Elite Sport in Hong Kong:

An Integrated Multi-disciplinary Model

Second Edition





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# CHAPTER 1

## INTRODUCTION

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In the world of high performance sport, it has become increasingly clear in recent years that individual success at the elite level is a function of the complex interplay of multiple factors acting in systemic concert. Apart from individual talent, and expert coaching to facilitate that talent, achieving and maintaining an edge over competitors requires a comprehensive support infrastructure to minimise risk and maximise results. Such a system requires significant funding, with concomitant responsibilities for fiscally responsible programming consistent with maintaining a culture of sporting excellence which is cost-effective, outcome-orientated, and accountable to public funding.

The Hong Kong Sports Institute (HKSI) is unique in Hong Kong in terms of providing a comprehensive and exclusive elite training environment for athletes and coaches aspiring to international success. The core of the handbook is focused around the support services provided through the Elite Training Science & Technology Division. In this handbook, we first briefly introduce the developmental history and the range of support available to elite athletes in Hong Kong. This is followed by an introduction to the supporting infrastructure available to athletes and coaches through the Elite Training Science & Technology Division.

### Developmental history of HKSI

As a centre for elite sports training, the HKSI has undergone many changes and developments over the years since it was first conceived as the Jubilee Sports Centre in 1976. Driving the development of the HKSI has been an unwavering commitment to the nurturing and development of sporting excellence in Hong Kong. It was the vision of the Royal Hong Kong Jockey Club in 1976 that led to the formal establishment of the Jubilee Sports Centre (JSC) in 1982, as a forerunner to a centralised institution of elite sports training for Hong Kong. This vision of providing comprehensive, integrated support to elite training and the professional development of the elite sport sector was realised on 13 March 1991 when Hong Kong's Legislative Council enacted the JSC Amendment Ordinance, formally establishing the HKSI, and consolidating the centralised training system for the pursuit of sporting excellence on the world stage. In 1994 the HKSI merged with the Hong Kong Sports Development Board (HKSDDB) to create a single statutory body with overall responsibility for elite training and sports development in Hong Kong.

On 1 October 2004, elite sport in Hong Kong again entered a new era with the dissolution of the HKSDDB and the reconstitution of the HKSI as an incorporated, rather than statutory body. What remained unchanged, however, is the focus on sporting excellence at the highest level and the role and identity of the HKSI as a delivery agent of elite training and development. The purpose of the dissolution of the statutory HKSDDB, and its replacement with the corporatised HKSI was to streamline and re-focus all resources within an athlete-centered elite sport system. The mandate of the new HKSI includes a number of specific objects outlining its role as a center for elite training and the pursuit of excellence in high performance sport (Table 1.1).

In 2008 the HKSAR Government allocated HK\$1.8 billion for the redevelopment of the HKSI's facilities to help ensure that our athletes would have world-class training facilities in Hong Kong. The final phase of the Redevelopment Project was completed in December 2014.

### Corporate profile

#### *Vision*

Guided by the HKSAR Government's current policy direction, and using its professional expertise in elite sport, the HKSI's vision is to become the region's elite training systems delivery leader by providing state-of-the-art, evidence-based, elite sports training and athlete support systems resulting in sustainable world-class sports results.

#### *Mission*

In its role as the HKSAR Government's elite sport training systems delivery agent, the HKSI is committed to working in partnership with the Government, the Sports Federation & Olympic Committee of Hong Kong, China and the National Sports Associations (NSAs) to provide an environment in which sports talent can be identified, nurtured, and developed to pursue excellence in the international sporting arena.

## Values

The HKSI holds that sport constitutes a fundamental social institution central to achieving public health goals of healthy, productive, united communities. The HKSI operates in an environment characterised by an uncompromising and ethical pursuit of excellence in sport through:

- integrity
- accountability to process and outcome
- collegial stakeholder engagement
- collaboration and teamwork
- inclusivity

- 
1. To provide an environment in which talented Hong Kong sportsmen and sportswomen have the opportunity to achieve at the highest level in sport and advancement in sports education.

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  2. To be a delivery agent in the provision of high performance sport for talented sportsmen and sportswomen in Hong Kong, under the policy direction of the Secretary for Home Affairs, enabling them to achieve international success so as to enhance the reputation of Hong Kong and benefit the community of Hong Kong.

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  3. To formulate and prepare schemes for and establish and take all necessary steps for the promotion, maintenance, improvement and advancement of the interest of the public in Hong Kong and elsewhere in elite sports and various related forms.

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  4. To work closely with the Sports Federation and Olympic Committee of Hong Kong, China and NSAs or other organizations of similar nature in the education, training and developing of Hong Kong talented sportsmen and sportswomen to achieve success in major games and international sporting events.

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  5. To work closely with the NSAs and other bodies in the identification of talents for elite sports training.

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  6. To co-operate with different sectors of the community, education and sports training institutions, both local and in other places, in the delivery of elite sports training programmes.

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  7. To assist athletes under training in the Institute in their education and vocational training and their longer term personal and career development.

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  8. To provide sports science and sports medicine services to elite athletes and coaches, catering for the needs of the athletes undergoing their sports training programmes.

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  9. To facilitate and sponsor elite sport-related research and studies; and to educate, disseminate knowledge and advice on these matters to the sports community for the enhancement of high performance sport.

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  10. To provide sports information service to meet the needs of athletes, coaches, NSAs, physical education specialists and sports science and sports medicine professionals.

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  11. To provide coach education and development, coach accreditation and coach registration.

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  12. To promote the exchange of information, experience, international understanding and goodwill in elite sport education and training.

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*Table 1.1 Objects of the Hong Kong Sports Institute*

## HKSI's 21<sup>st</sup> century elite training system

Individual success in elite sport depends on a systematic approach to optimize the complex interplay of the multiple factors that drive high-level performance. In addition to individual talent and expert coaching to facilitate that talent, the process of helping a gifted athlete reach his or her full potential requires a comprehensive support infrastructure to minimise risk and maximise results. It also demands a scientific, evidence-based, long-term commitment from the earliest stages of talent identification all the way through to the athlete's peak performance years and beyond.

The HKSI's elite sport system framework combines policy/management and science models to articulate a 21<sup>st</sup> century elite training delivery system (Figure 1.1). It is an athlete-centred system bounded by best practice principles of corporate governance on the one hand, and the scientific principles of the biopsychosocial model on the other. The biopsychosocial model of athlete development recognises the complex interaction of biological, psychological and socio-cultural factors which impact on athlete development. The HKSI is structured to provide centralised, integrated support systems targeting all aspects of the athletes' physiological, psychological, social support, and personal development needs.



Figure 1.1 21<sup>st</sup> century elite training system at HKSI

The critical success factors, which are directly related to the systematic development of elite athletes, are portrayed inside the circle in Figure 1.1, while support activities which are not directly related to individual athletes' development, but which improve the provision and efficient functioning of the elite training system are portrayed outside the circle.



## Funding support

### *Elite Vote Support Scheme*

The HKSI is the HKSAR Government's delivery agent responsible for providing a world standard training and support environment for high-performance athletes, to enable them to excel in the international sporting arena. Under the HKSAR Government's Elite Vote Support Scheme, the achievements of both senior and junior athletes at major international competitions comprise the selection criteria for identifying the high-performance sports to be supported by the HKSI for a four-year period. Sports are categorised into three levels, Tier A\*, Tier A and Tier B. A review is conducted every two years and is aligned with the Asian Games and the Olympic Games cycles in order to provide stable support for the sports within the four-year support cycle. In 2016/17, 17 Tier A Sports, four of which had been selected as Tier A\* Sports, were supported by the HKSI and provided with funding for elite training, dedicated coaching teams led by a Head Coach, full Sports science and Sports medicine support, and athlete development programmes. Funding and support were also provided for 13 Tier B Sports.

### *Direct financial support to athletes*

Since 2007-08, enhanced direct financial support to athletes has been launched, with increased funding from the HKSAR Government. This is to provide elite athletes with a more financially stable environment to undergo training and compete in Major Games.

There are four funding schemes for the support to elite athletes:

**a. *Elite Training Grant (ETG)***

The ETG is provided to HKSI Scholarship Athletes of Elite Sports (Tier A) and elite athletes of non-Elite Vote-Supported Sports under the Individual Athletes Support Scheme.

**b. *Sports Aid Grant (SAG)***

The SAG provides direct financial support to elite athletes of non-Elite Vote-Supported Sports not under the Individual Athletes Support Scheme, and elite athletes of Elite Sports (Tier A) not under the HKSI Sports Scholarship Scheme.

**c. *Sports Aid Grant for Athletes with Disabilities (SAGD)***

The SAGD provides direct financial support to Hong Kong athletes with demonstrated performance and potential to achieve or maintain success in the international sports arena.

**d. *Individual Athletes Support Scheme (IASS)***

Athletes of non-Elite Vote-Supported Sports and secondary disciplines of Elite Sports (Tier A) who meet the funding criteria will be provided with a programme funding via their respective NSAs to support their additional elite training needs.

## Sports Scholarship Scheme

Typically, athletes' development pathway begin with the feeder system and training programmes provided by respective NSAs, where they receive elementary training to enhance their athletic competence.

Through discussions and recommendations between the HKSI and respective NSAs, athletes who meet the entrance requirements under the Sports Scholarship Scheme will be eligible to register as the HKSI Scholarship Athletes. As they progress, they will move to increasingly higher levels of performance until they reach their full potential.

The Sports Scholarship Scheme provides a comprehensive support system for high performance athletes searching for international success. We believe that athletes can train full-time and succeed at the highest level, without sacrificing their academic development. During their time with us, athletes will develop the skills and physical qualities to excel at their sport, and also build the self-esteem, leadership talents, cooperation and teamwork that will not only add to their sporting capabilities, but also help them to excel in life and society, in their post-athletic life.



Figure 1.2 Collaborative approach to support HKSI Scholarship Athletes

The Sports Scholarship Scheme supports outstanding athletes in Elite Sports (Tier A), and extends to outstanding individual athletes in sports supported under the IASS and sports for athletes with disabilities. Currently, over 1,000 athletes are supported across three categories under the Scheme:

**a. Elite Athletes**

Successful applicants of ETG and SAGD are supported under the Sports Scholarship Scheme, awarded with Elite A+, Elite A, Elite B+, Elite B, Elite C and Senior Squad.

**b. Junior Athletes**

Successful applicants of ETG are supported under the Sports Scholarship Scheme, awarded with Junior A, Junior B and Junior Squad.

**c. Potential Athletes (For Elite Sports Only)**

Athletes with sports talent and potential recommended by NSAs may receive local training support at the HKSI.

## Elite athletes lifestyle support

### *Educational and career development support for elite athletes*

As the key delivery agent for high performance training for Hong Kong's elite athletes, the HKSI recognises the importance of a "whole person" development approach to providing services to athletes, and accordingly offers athletes educational and career planning services to cater to the different needs of athletes at various stages of their sporting career. One of the main elements of the HKSI's 2011-2015 Strategic Direction is to facilitate integrated educational opportunities for athletes to allow them to train as full-time professional sportsmen and women whilst pursuing their educational goals ("dual career model").

In line with this direction, the HKSI has implemented a number of programmes to address the needs of the athletes by providing them with the support on education and career development during and after their sports career. Overall, the HKSI provides general education and career planning services to athletes through the Athletes Educational and Vocational Development Programmes such as the Elite Athletes Tutorial Support Programme, athletes may receive one-on-one instruction in languages, mathematics and other subjects. Other programmes include the Elite Coaching Apprenticeship Programme which provides a pathway for athletes to gain on-the-job work experience and prepare for their coaching profession. The Elite Athletes Development Programme provides training in areas such as communication, time management and financial management skills. Additionally, athletes may also apply for grants to cover tuition fees as well as subsistence allowance through the Hong Kong Athletes Fund.

In recent years, the HKSI has worked with the education sector to develop new educational programmes for elite athletes, namely the Secondary Education Programme; the Professional Accreditation Programme and the Flexible Tertiary Education, with a view of achieving a balance between a commitment to full-time athletic training and continuing to pursue further education and improve athletes' further career prospects.

### Awards

#### *Athlete Incentive Awards Scheme*

Established by the HKSI in 1994, the Athlete Incentive Awards Scheme provides cash incentives to local medal winners at various Major Games, with an aim to show recognition and appreciation to their hard work and dedication.

#### *Outstanding Junior Athlete Awards*

Title sponsored by the Sports for Hope Foundation, presented by the HKSI and with the support of the Sports Federation & Olympic Committee of Hong Kong, China and the Hong Kong Sports Press Association, the Outstanding Junior Athlete Awards programme is to recognise outstanding sports achievements of local talented young athletes on a quarterly basis and encourage athletes to strive for excellence.

### High performance coaching

Individual success in elite sport depends on a systematic approach to optimise the complex interplay of the multiple factors that drive high-level performance. Expert coaching is one of the key elements to help a gifted athlete reach his or her potential and achieve good results. The HKSI works in close collaborations with the Tier A Sports in employing high performance coaches in order to achieve the agreed training and competition goals of elite training. Led by a Head Coach, each coaching department has a team of coaches and assistant coaches to plan, design, implement and evaluate the elite training programme, ensuring professional and effective coaching to bring out athletes' full potential.

### Coach education

The HKSI has established a comprehensive range of coaching services to meet the needs of athletes and local sports development. The Coach Education Department is responsible for implementing the Coach Education Programme and the Coaching Awards in Hong Kong on behalf of the Hong Kong Coaching Committee (HKCC). The HKCC is a joint committee of the Sports Federation & Olympic Committee of Hong Kong, China and HKSI. In 1999, the HKCC became a Category A member of the International Council for Coaching Excellence.

### Elite training science and technology

The HKSI uses the multi-disciplinary biopsychosocial model to formulate its support strategy in order to provide science-based, athlete-centred support for elite training. The six centres in the Elite Training Science & Technology Division, namely the Scientific Conditioning Centre, Sport Biomechanics & Technology Centre, Sport Nutrition Monitoring Centre, Sport Psychology Centre, Sports Medicine Centre and Sports Information Centre, work as a team to identify the various training problems and concerns, and develop evidence-based solutions with the coaches. The support procedures are regularly updated through continuous monitoring, discussion and benchmarking against the latest research data.



### *Scientist-practitioner model of service provision*

Research and practice are mutually linked, each informing the other. In this regard, service providers are scientists, using evidence-based interventions. The service provided needs to be state-of-the-art, cutting edge science. This is not possible without ongoing applied research specific to the Hong Kong elite athlete population. The Division conducts applied scientific research which directly informs the high performance needs of elite athletes and coaches. Multi-disciplinary, collaborative research is regularly conducted both internally and in collaboration with local, and mainland academic and sports institutes. Key areas of research include physiotherapy, Chinese manual therapy, psychology, physiology, biochemistry, biomechanics, strength and conditioning, nutrition.

### *International exchange*

In order to stay at the forefront of global trends and to promote exchange between the HKSI and other elite sport professionals in applied sports science and medicine, the Division organises various seminars, lectures and workshops for athletes and coaches, NSAs, local and overseas tertiary and sports institutes; and launches various exchange programmes with collaborative partners.

## **Outcomes**

The primary outcome focus of the elite sport system in Hong Kong is medal success at the Asian Games and developing medal success at the Olympic Games. At the 2014 Asian Games, Hong Kong won a record 43 medals, there is a continuation of the increasing trend in medals and in positions 4-8, at each successive Asian Games from 2006, 2010, to 2014, with Hong Kong's share of medals also increasing with each edition from 2.1%, to 2.5%, to 3.0%. Hong Kong entered the top 10 of the 2014 Asian Games medal table (finished 10<sup>th</sup> place) for the first time. At the Olympic level, Hong Kong's only Olympic gold medallist, Ms Lee Lai-shan, won gold in the windsurfing event at the 1996 Atlanta Olympics. At the 2004 Athens Olympics, Mr Ko Lai-chak and Mr Li Ching, brought home the silver medal in the men's doubles table tennis event. At the 2012 London Olympics, Ms Lee Wai-sze, won a bronze medal in the women's keirin cycling event. These athletes have been supported and trained over many years within the elite training programme at the HKSI. Nevertheless, it is only with HKSI's collaboration with the NSAs and the support of the Sports Federation & Olympic Committee of Hong Kong, China, that these results can be achieved. This long-term, systematised preparation and multi-lateral collaboration necessary for international success at the highest levels is the norm in today's elite sports world.

### Conclusion

The biopsychosocial support servicing model at the HKSI is consistent with government and corporate concerns for maintaining a culture of sporting excellence in Hong Kong which is cost-effective, outcome oriented, and accountable to public funding. In striving to achieve standards of best practice, within a service sector that demands and expects excellence from all support staff, one of the challenges is maintaining an elite group of professional staff that is consistently motivated and passionate about facilitating the sporting achievements of Hong Kong's athletes and coaches. Accountability to service standards must be maintained with regular reviews, reflections and with ongoing professional development. At the HKSI excellence is conceptualised as a continuum, making it possible to constantly evaluate and review structures and functions without the underlying assumption of dysfunction or failure.

Additionally, it is worth considering that the words “effective” and “outcome” take on very specific meanings within the context of elite sport. When the outcome is defined as achieving standards of excellence in international sport, achieving what is possible only within the top few percentiles of any population, then the word ‘effective’ becomes inapplicable. “Effective” is just not good enough. Outcomes of excellence require inputs of excellence.

The following chapters in this handbook will describe how each Centre in the Elite Training Science & Technology Division uniquely and collaboratively articulates this mission of excellence. The theoretical framework, principles and scope of practice of each area will be outlined in the context of the operational model of the Division, and illustrated with case studies.

# CHAPTER 2

## SCIENTIFIC CONDITIONING CENTRE

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### Introduction

The Scientific Conditioning Centre consists of three units, Scientific Assessment, Strength and Conditioning, and Talent Identification and Development. The Centre works closely with other centres within the Elite Science & Technology Division such as psychology, nutrition and biomechanics to develop and implement science-based strength and conditioning programmes designed to optimise athletes' performance by improving their cardiovascular system, power, strength, speed, agility, and mobility, thus enabling them to perform to their fullest potential.

This is achieved through the use of scientific assessments, such as the assessment of cardiovascular function, blood lactate, other blood chemistry, strength, and a range of other technology based tests that physiologists use in both the laboratory and the field to design and monitor training to bridge the gap between training theory and applied training.

This ensures the effective periodisation, prescription of training load and intensity and adequate rest, which maximizes the desired physical outcomes. Strength and Conditioning Coaches work closely with coaches and athletes developing conditioning programmes and coaching exercise technique. Programmes are designed for athletes, based on the specific requirements of the sport and the needs of the individual athlete as well as to address muscular imbalances.

In addition to physiological testing, monitoring and strength and conditioning services; the Centre uses its talent identification programmes in partnership with national sporting associations to verify potential talent, monitor progress and assist in the long term athlete development pathway for athletes.

## 2.A Scientific Assessment

The Scientific Assessment Unit uses various technologies and equipment both in the laboratory and field, the Unit conducts tests and monitors training in a precise and meticulous way in order to ensure the quality and reliability of the data. On-field fitness testing and training monitoring are regularly conducted and subsequent training advice is given to colleagues, athletes and coaches to best suit the needs of different elite sports. In addition, the Unit cooperates with a wide range of elite sports in terms of monitoring athletes overseas. It provides various supports such as day-to-day conditioning training measurements, training monitoring and specific warm up and recovery treatments to ensure athletes recover well and are able to deliver optimal performance.

### SERVICE PROVISION

#### 1 Scientific assessment services

##### 1.1 Assessment of aerobic capacity

###### *Incremental (Step) Test*

The incremental test has 2 purposes. The first purpose is to elicit maximal oxygen uptake ( $VO_{2max}$ ). Coaches are interested in  $VO_{2max}$ , as  $VO_{2max}$  is a determining factor in many elite sports. Speed at  $VO_{2max}$  is also useful in predicting running performance from 1,500 m – 5,000 m. The second purpose is to determine oxygen uptake ( $VO_2$ ) and running speed at the anaerobic threshold point. The anaerobic threshold point is the fastest running speed at which blood lactate remains at a relatively steady state. Above this speed, lactate will rise progressively until exercise is stopped or intensity is reduced. Whilst lactate does not directly cause fatigue, the appearance of lactate corresponds with by-products that contribute. For example, an increase in hydrogen ions will signal to the brain that homeostasis has been changed; therefore the brain needs to regulate the intensity of exercise and forces the athlete to slow down. So when the brain receives the signal that fatigue is building up, it decreases muscle fibre recruitment and movement if affected.

The incremental test is divided into two parts: (1) submaximal incremental test, and (2) maximal oxygen uptake test.

- (1) Submaximal incremental test – This part allows the investigation and determination of anaerobic threshold – the point at which there is a marked increase in lactate production and the rate of lactate accumulation is greater than lactate removal. The test measures athlete's oxygen uptake, heart rate and blood lactate responses at a range of running speeds that equate to those used in training and competition. Typically, the athlete will complete 4-7 stages of 3 minutes each. The starting speed is relatively low (jogging) with a gradient at 1%. As the test progresses, the speed will be increased by 1 km/h at each stage (Figure 2.1). Following each stage, there is a 30-second rest period for taking blood lactate samples. The first part of the test will be terminated once the tester determines the athlete has reached his/her anaerobic threshold.



- (2) Maximal oxygen uptake test - This part is used to elicit  $\text{VO}_{2\text{max}}$ . After a few minutes of recovery, the treadmill is set to the speed just prior to the speed at which athlete's individual anaerobic threshold was determined. During this part of the test, the treadmill speed remains constant whilst the gradient is increased by 1% after each minute. The athlete is instructed and encouraged to run as long as possible, i.e. to complete exhaustion. Once the athlete can no longer continue the test, blood lactate samples are taken to determine maximal lactate value and the  $\text{VO}_{2\text{max}}$  value is measured.

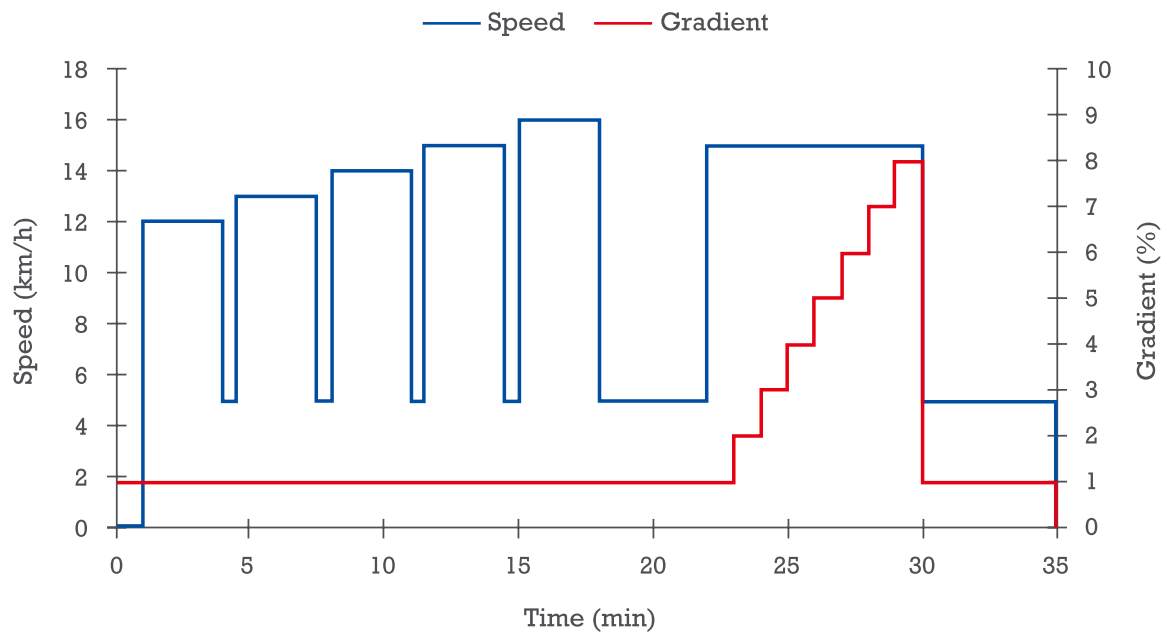


Figure 2.1 Incremental test protocol



Figure 2.2 Incremental test

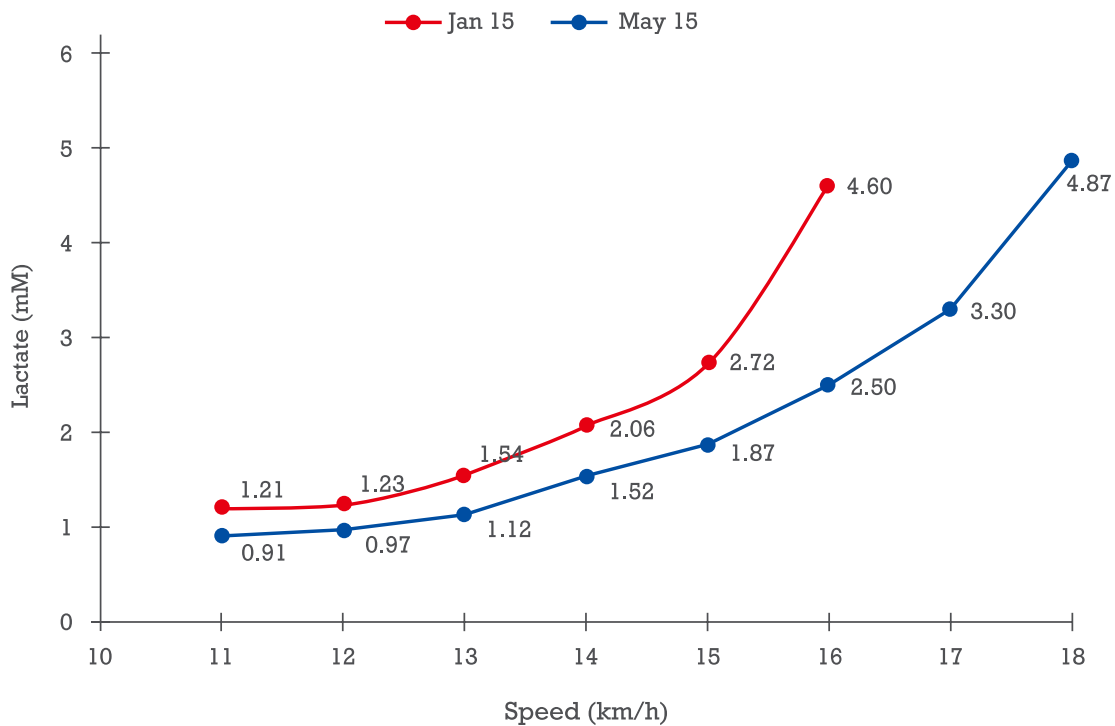


Figure 2.3 Changes in blood lactate

Figure 2.3 shows the relationship between running speed and blood lactate during two separate tests completed 4 months apart. In the January test, lactate steadily increased until the athlete reached a speed of 15 km/h. After this speed, lactate increased more sharply, indicating that the anaerobic threshold had been reached. In May, after 4 months of training, the athlete completed a second test in order to assess his/her response to the training stimulus during this period. There was a clear rightward shift in the speed-lactate curve, indicating that the athlete can now run at a faster speed without a substantial increase in lactate from baseline values. It is not until after 17 km/h that there is a marked increase in lactate. Therefore the athlete has improved his/her aerobic capacity either by delaying the build-up of fatiguing products and/or improving lactate removal.

Whilst athletes who compete in sports involving running actions will do this test on a treadmill, we will also test the cyclists and rowers on the bicycle and rowing ergometers, respectively.

### Fencing endurance test

The movement patterns in fencing are considerably different to those exhibited in more traditional endurance capacity tests using exercise ergometers. This endurance test takes into account the specific load during competition, like fencing-specific footwork, changes of direction, forward and backward movements and holding weapon. (Figure 2.5)



Figure 2.4 Fencing endurance test

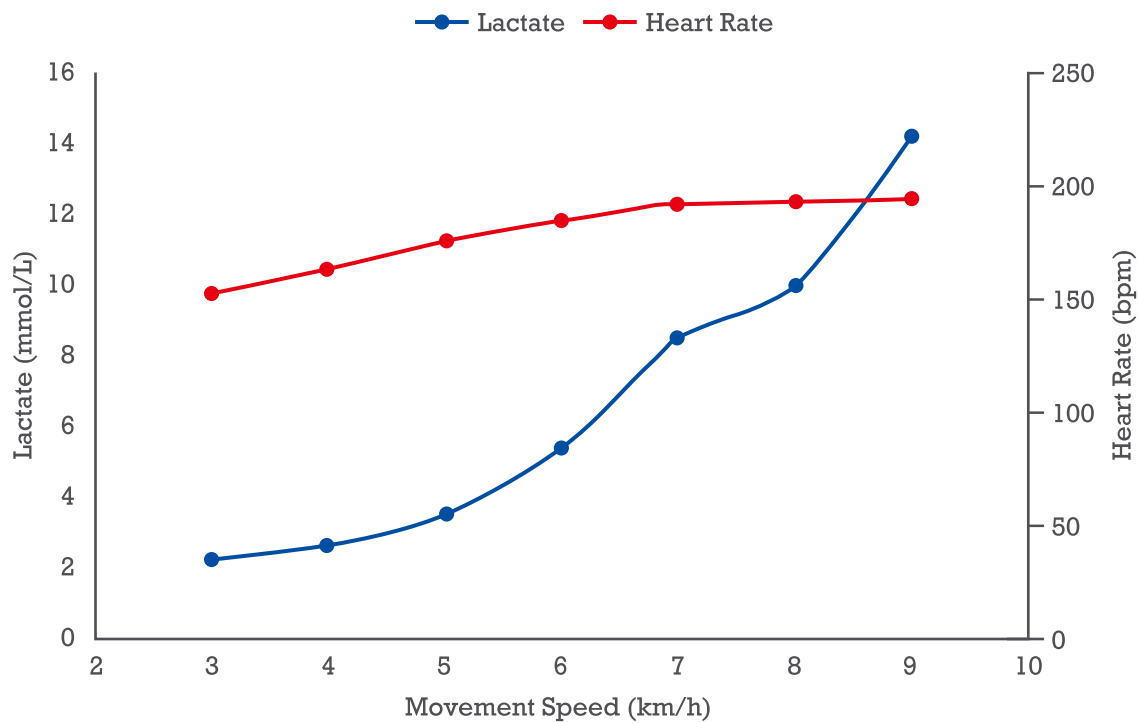


Figure 2.5 Fencing specific field test; response of heart rate and lactate

### 20 m Shuttle run

Schoolchildren taking part in our talent identification testing program are required to run back and forth on a 20 m course. They must reach the 20 m line before or at the time a sound signal is emitted from a pre-recorded CD. The test can estimate maximal aerobic power based upon the age of the children and the speed level at which they have reached before failure.



Figure 2.6 20m shuttle run

### 7 x 200 m Swim step test

The first repetition of the test is completed at a pace which corresponds to 70% of the swimmer's personal best (PB) time. Following each repetition, there is a 3-minute recovery period before the start of next 200 m. During this period, blood lactate sample is taken. Each subsequent repetition should be completed at a slightly faster pace than the previous (75%, 80%, 85%, 90%, 95% and 100% of PB). Lactate responses can be plotted alongside 200 m times and coaches can assess the impact of the athlete's training. (Figure 2.7)

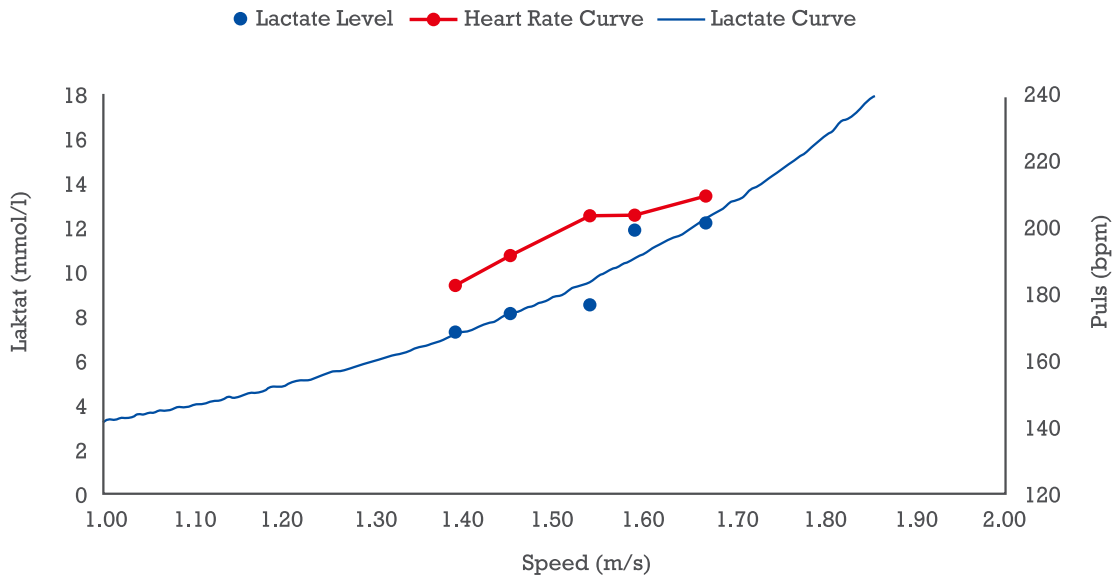


Figure 2.7 Heart rate and lactate responses from a swimming specific test

## 1.2 Assessment of anaerobic capacity

### 30 seconds Wingate anaerobic test

This test is performed on a cycle ergometer which gives an indication of peak power, average power and fatigue index. The peak power reflects the ability of leg muscles to produce high mechanical power in a short time, whilst the average power gives an indication of their capacity to sustain extremely high power outputs. The fatigue index is useful for helping the coach in assessing which areas an athlete may need to focus on in training. (Figure 2.9)



Figure 2.8 Wingate anaerobic test

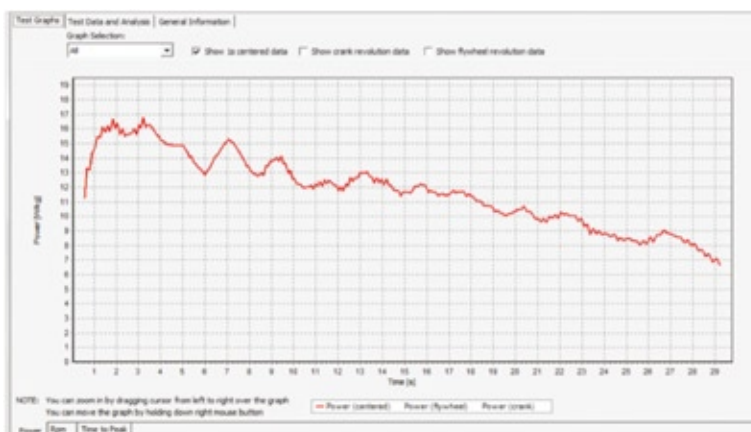


Figure 2.9 Assessment of power



### *6 x 50 m Swim sprint test*

A swimmer performs a maximal effort of 50 m swim every 3 minutes until he/she has completed 6 swims. Times are recorded for each sprint therefore the coach will then understand the athletes' 50 m race pace and his/her resistance to fatigue. Lactate samples are taken at the end of the test to elicit maximal value and then again after 20 minutes to give an idea of an athlete's recovery ability. Subsequently, the maximal lactate value and fastest sprint time will provide an indication of the swimmer's anaerobic capacity.

## **1.3 Maximum power**

### *Rowing 10 stroke max*

This test is performed on a rowing ergometer for the determination of peak power output. Peak power is an important parameter in rowing as it sets an upper limit for performance during races. It is impossible to maintain maximum power for more than a few seconds; if a rower's peak power is higher, he/she has the potential to increase his/her speed at certain time points during the race. When tactics are executed well, the athlete



*Figure 2.10 10 stroke max test*

with the high maximum power is more likely to finish the race on the podium – even if athletes are matched for endurance ability.

### *Windsurfing pumping 20 s and 90 s test*

The tests are performed on a windsurfing ergometer which has been designed in our laboratory to better reflect on-water sail pumping conditions. The 20 second test gives us an indication of the windsurfer's maximum power and how quickly he/she is able to produce these high power outputs, whilst the 90 second test allows us to assess his/her resistance to fatigue. Fatigue resistance is measured by comparing the percentage difference in power output from the peak to the end of the test. Blood lactate samples are taken immediately after the test to profile athlete's anaerobic capacity.

## 1.4 Isokinetic muscular strength and endurance

### *Cybex and Biodex Testing and training*

Isokinetic devices are used to precisely test muscular strength around joints and often used in rehabilitation from injury. During isokinetic strength testing, an athlete performs isolated movements on a specialized machine, which records a number of important parameters that are useful for his/her rehabilitation programme. Specifically, the machine is able to capture the profile of the force-velocity or torque-angle characteristics of a muscle group or limb, muscle fatigability and recovery and range of motion. For athletes who perform in sports involving high-velocity acceleration and deceleration, it is typical to test the concentric quadriceps and hamstring strength levels and ratios which potentially indicates whether an athlete has a greater risk of suffering from hamstring injury due to any muscle imbalances.



Figure 2.11 Isokinetic test

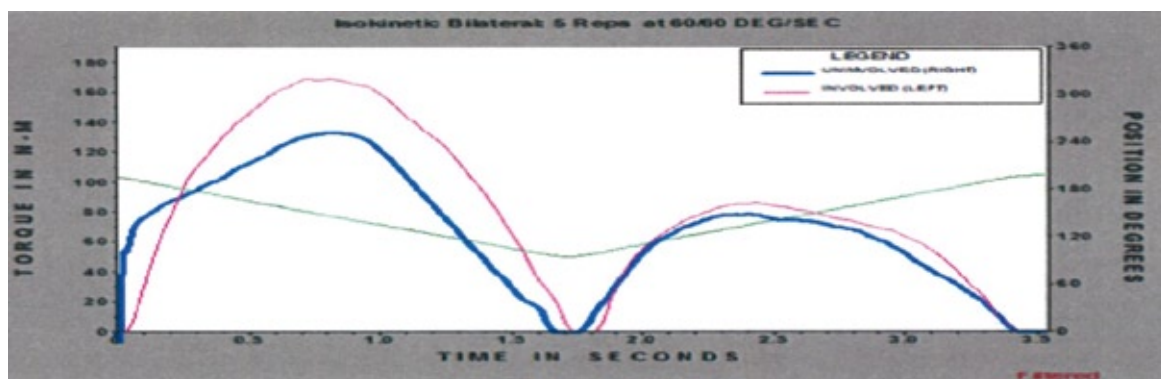


Figure 2.12 Isokinetic test force curves

## 1.5 Flexibility test

### *Sit and reach*

This test is a common measure of flexibility which specifically measures the flexibility of the lower back and hamstring muscles. Athletes who suffer from lumbar lordosis, forward pelvic tilt and lower back pain are likely to experience stiffness in this area.

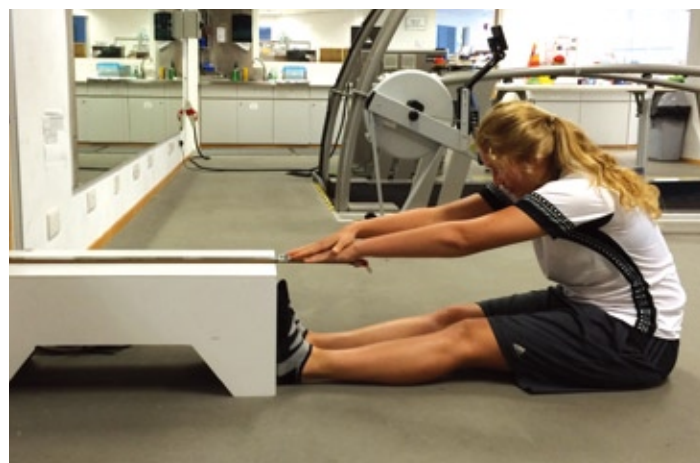


Figure 2.13 Sit and reach

### Shoulder rotation

An athlete performs this test by holding a long measuring stick with marks at every 5 cm intervals. With a wide overhand grip and arms fully extended, he/she is instructed to slowly move the stick from the front of the thighs, up and over the head, to the back of the thighs. The stick should remain parallel to the floor with the elbows locked. The athlete then returns the stick to the starting position in the same manner. If the attempt is successful, the athlete will perform another attempt with a narrower grip on the stick.



Figure 2.14 Shoulder rotation test

## 1.6 Respiratory muscle strength assessment and lung function test

Some athletes have been found in regular  $VO_{2max}$  testing to have the problem of under-ventilation during maximal exercise. Their  $SpO_2$  (the level of oxygen in their blood) in the tests also dropped below 92% during maximal exercise. Therefore we use a series of pulmonary function tests and consultation with medical doctors, to determine if athletes may have weak respiratory muscles which could contribute to low  $SpO_2$ .

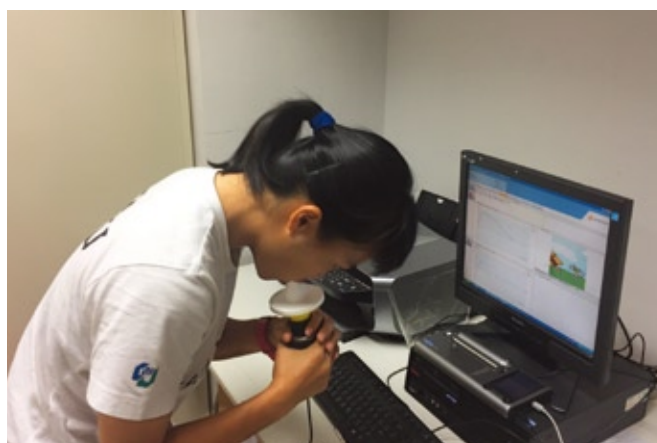


Figure 2.15 Lung function test

Respiratory muscle training programmes focusing on inspiration can be recommended to athletes. In an 8-week programme, athletes are trained twice daily using a commercially available device with adjustable breathing resistance. Each session



Figure 2.16 Respiratory muscle training

consisted of 30 breaths. At the same time, they participated in a running programme aimed at training their anaerobic threshold (AT). After 8 weeks of respiratory muscle training and AT training, the  $SpO_2$  of the athletes during the running sessions was elevated. Their ventilation during maximal and sub-maximal exercise was also increased as found by a  $VO_{2max}$  test (Figure 2.1)



## 1.7 Agility tests - sport specific (such tests are used across many elite sports such as badminton, fencing, table tennis, squash etc)

### *Repeated change of direction (RCOD) - Rugby*

The purposes of the test is to perform change of direction in repeated 180° turns, assess speed (acceleration and deceleration), measure anaerobic capacity, and to calculate fatigue over multiple intense exercise bouts. Each athlete runs 5 m out and back from the starting line, 10 m and back, then sprints as far as possible all within 10 seconds. He/she then has 20 seconds to rest and return to the starting line to get ready for another trial. Each athlete performs 7 successive trials during the RCOD test.

Assessment of performance considers the furthest distance reached, the total distance covered over the test and the distance in each trial. Rate of fatigue can be calculated from the difference between the first trial and the last (or the furthest against the shortest distance).



Figure 2.17 Repeated change of direction test

| Test Date       | Athlete Name | Repeated Change of Direction Trials |    |    |    |    |    |    | Best Distance | % Improvement | Fatigue |        | % Improvement |
|-----------------|--------------|-------------------------------------|----|----|----|----|----|----|---------------|---------------|---------|--------|---------------|
|                 |              | 1                                   | 2  | 3  | 4  | 5  | 6  | 7  |               |               | (m)     | (%)    |               |
| Thu, 1 Jan 2015 | AB           | 45                                  | 43 | 39 | 37 | 36 | 35 | 34 | 45            | -             | 11      | 24.40% | -             |
| Fri, 1 May 2015 | AB           | 48                                  | 45 | 40 | 38 | 36 | 35 | 35 | 48            | 6.70%         | 13      | 27.10% | 10.8          |
| Sat, 1 Aug 2015 | AB           | 51                                  | 47 | 41 | 39 | 38 | 38 | 37 | 51            | 6.30%         | 14      | 27.50% | 1.4           |

Table 2.1 Sports specific agility test data



### AB's RCOD test results

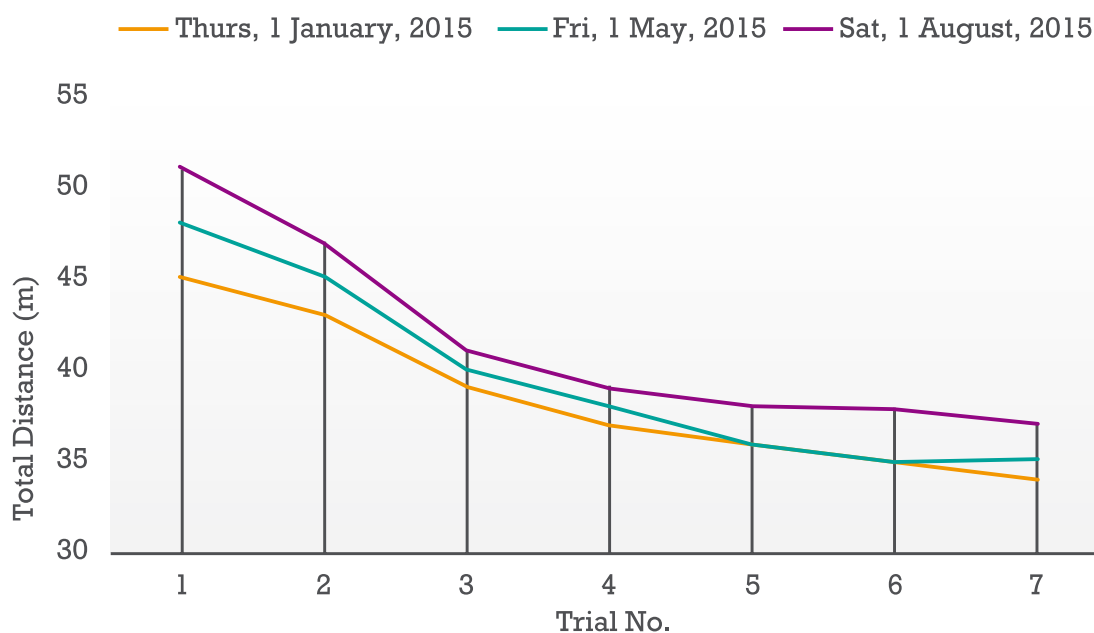


Figure 2.18 Sports specific agility test data

The example results in Table 2.1 and Figure 2.18 above show athlete AB's performance in pre-, mid- and post-training season. High scores in all of the 1<sup>st</sup> sprints indicate athlete AB has a good base of speed and agility, however athlete AB's fatigue rate is high with large differences between first and final sprints. Over the season athlete AB focused on developing the peak sprint distance, but less on maintaining such a high performance for longer. Over the 3 testing periods, athlete AB's speed and agility developed but his recovery ability (anaerobic endurance) still remain one of their focus points.

A key factor affecting speed and agility is body weight. With increasing focus on strength and power development in modern 7s, rugby players often have muscle mass gain goals. Players must acclimatise to their increased weight any effect on their movements and altered centres of gravity before they can expect to perform with improved agility and speed.

The data from an RCOD test gives insight into speed, anaerobic endurance and agility—key components of a fast and 'open' sport in a large space. These qualities can be improved on the field and/or with resistance training.

#### *Repeated sprint test (RSA) - Rugby*

The purposes of the test is to measure pure speed (including acceleration), anaerobic capacity, and fatigue over multiple intense exercise bouts. An RSA test consists of 6x30 meter sprints within 2 minutes. Once an athlete starts the first sprint, he/she has 20 s to reach the 30 m and turn around to start the next sprint back to the previous starting line. Timing gates are set opposite each other and timing is recorded when the athlete breaks the circuit by stepping through the gates.

| Athlete Name | 30m Sprint Trials (s) |     |      |      |      |      | Total Time (s) | Average Time(s) | Fatigue Ratio | Fastest 30m     | Slowest 30m     |
|--------------|-----------------------|-----|------|------|------|------|----------------|-----------------|---------------|-----------------|-----------------|
|              | 1                     | 2   | 3    | 4    | 5    | 6    |                |                 |               |                 |                 |
| AB           | 4,086                 | 4.1 | 4.24 | 4.32 | 4.37 | 4.41 | 25.5           | 4.254           | 7.24%         | 1 <sup>st</sup> | 6 <sup>th</sup> |

Table 2.2 Repeat Sprint Test Data

The example data (Table 2.2) shows the athlete’s sprint times and his/her rate of fatigue over the trials. Possible goals for this athlete could be to improve peak speed development for his/her initial sprints or to reduce fatigue over the repetitions.

The test is useful for assessing pure speed maintenance acceleration, anaerobic capacity and fatigue over multiple high intensity bouts. The short recovery period between sprints (~15-16 s) limits resynthesis of the key energy source for rapid movements (phosphocreatine, PCr) and metabolite clearance (such as lactate). Limiting the fuel source, reducing waste clearance and increasing muscle fatigue all lead to progressive performance decline with every sprint, this reflects the high pace of 7s matches which entail repeated all-out bursts of speed with short rest times.

*Reactive agility test – Rugby*

“Read and react” - definitions of agility are expanding to address both physical and cognitive elements of the skill, therefore our laboratory has introduced a Reactive Agility Test to the battery of rugby agility measures as an ‘open’ test to assess athletes’ ability to perform quick changes of direction in response to visual cues. The purposes of the test is to assess change of direction (<45° change of direction followed by a 5m sprint) and cognitive factors (anticipation and reaction to a stimulus), examine decision-making accuracy, and measure left/right side imbalances.



Figure 2.19 Reactive agility test

| Test Date       | Athlete Name | Right 1 | R2   | Left 1 | L2   | Average of Fastest L&R | % Improvement |
|-----------------|--------------|---------|------|--------|------|------------------------|---------------|
|                 |              | (s)     | (s)  | (s)    | (s)  |                        |               |
| Thu, 1 Jan 2015 | AB           | 1.8     | 1.9  | 2.1    | 1.86 | 1.83                   | -             |
| Fri, 1 May 2015 | AB           | 1.65    | 1.8  | 1.85   | 1.72 | 1.69                   | 10.10%        |
| Sat, 1 Aug 2015 | AB           | 1.54    | 1.68 | 1.61   | 1.61 | 1.58                   | 6.50%         |

*Table 2.3 Reactive Test Data*

During this test, an athlete stands 5 m opposite a mock attacker who uses evasive footwork to run with a ball to the left or to the right. The athlete must read the attacker's body movements to anticipate which direction the attacker will go, then run as quickly as possible through the appropriate timing gates. Each athlete performs a minimum of 4 trials (2 to each side) against the same attacker who follows a randomised order of instructions on how to move, e.g. "step forward onto your left foot, cut to the right" from 6 variations.

Assessment of performance is based on the speed and accuracy of decision-making. Coaches use high speed cameras to break down the rugby specific tracking techniques and evaluate efficiency.

The above example data (Table 2.3) shows athlete AB performing faster right turns and overall good speeds to both sides. Coaches might set athlete AB physical goals to increase his/her lower limb power and left turn speed so as to improve overall speed and correct the left/right imbalance. Athlete AB should also practice his/her cognitive skill and reaction time through simple 1 vs 1 drill and consciously working on game skill acquisition.

### *Agility test - Badminton*

The purposes of the test is to measure speed (acceleration, deceleration), assess change of direction (in various angles: 180°, 120°, 67°, 107°) and accuracy of shots. An athlete goes through a pair of timing gate at the centre of the base-line to start the test. He/she then has to run through the marked centre of the court before performing a forehand shot near the right side of the net, then the right midcourt, then the right back corner. Between each shot, the athlete returns to the marked centre point. The athlete repeats the same movement on the left side with backhand shots before finishing the test by running through time gates at the net-line (the net is removed prior to the test). In the front and at the back court, the face of the racquet is required to touch the tip of 1.15 m and 0.77 m tall poles respectively, and at the midcourt swing the athlete must strike a shuttlecock balanced on the ground (feathers down). Throughout the test, the athlete's torso must remain facing forwards.

This test assesses athlete's ability to reach the forecourt to return a tight and tumbling shot near the net before sprinting to the rear court to defend a smash, reflecting the strategies used in badminton attack plays.



Figure 2.20 Badminton agility test

### *Skipping – Table tennis*

The purpose of the test is to measure foot-speed, anaerobic capacity, and assess hand-foot coordination. The test counts maximal number of single-wave skipping in 60 s. Results from this test indicates an athlete's foot and hand coordination, speed of ankle and knee movement as well as muscle fatigue over a medium period of high intensity work using the anaerobic alactic energy system. Table tennis matches draw predominantly upon the anaerobic alactic system for energy, thus tests of this capacity are key for coaches to assess training and selection.

### *Lateral agility test – Table tennis*

The purposes of the test is to measure lateral speed (acceleration, deceleration), assess change of direction (left, right; while torso facing forwards), and measure anaerobic capacity. An athlete performs side steps 3m-apart as many times as possible in 30s. One foot of the athlete has to touch either the left or right line to start the test. A repetition is counted whenever the lateral foot touches the side line (left foot on left line, right foot on right line).

The test imitates movement of returning a rapid succession of shots from alternating sides of the table. It is important that an athlete has fast footwork while keeping the torso facing forwards to return hits.

### *2-4-2 Test – Fencing*

The purposes of the test is to measure speed (acceleration, deceleration in fencer's step), and assess change of movement direction (forward, backwards). Performed on a piste without weapon, an athlete assumes the fencer's stance with the whole front foot behind the starting line. By using the fencing step, the athlete moves forward until the torso passes the 2 m mark, then he/she performs the step backward until the whole front foot is behind the starting line again. This is repeated to the 4 m mark, then again to the 2 m. During the test, the torso must remain facing forwards at all times. Each athlete performs 3 trials with the fastest trial being recorded.

Footwork is a core skill in fencing and it has to be performed with minimal effort so athlete's focus can remain upon their blade work in attack and defense. Using the 2-4-2 test, coaches can set their players speed goals which is achievable with repetitive practice and speed training; resistance exercises can also improve fencing athlete's acceleration and deceleration.



Figure 2.21 2-4-2 test

## 2 Training services and monitoring

### 2.1 Laboratory training and monitoring

#### *Heat acclimatisation*

When athletes have to compete in hot ambient condition, it is important that they acclimatise to the condition beforehand to gain biological adaptations, lower physiological strain and improve exercise capacity in the heat. In our laboratory, we can simulate the ambient conditions of the competition venue in our environmental chamber. Typically, a heat acclimatisation session should last for at least 60 minutes per day and induce an increase in core temperature, skin temperatures and stimulate sweating. To maximise all benefits, the heat acclimatisation process should last approximately 2 weeks.

#### *Altitude training*

Inside HKSI's Athlete Hostel, we have two sealed rooms which are used to simulate a higher altitude with reduced oxygen. Up to a maximum of 4 athletes can stay in the rooms, causing their bodies to adapt to the lower oxygen content by producing more red blood cells and haemoglobin. Other benefits include increased number of mitochondria, increased capillary density and increased use of free fatty acids. These potential adaptations are particularly important for athletes competing in endurance sports like triathlon and distance running; and for those competing at altitude.





Figure 2.22 Altitude room

- *Live high-train-low*

At the HKSI, we implement a live-high-train-low protocol, providing athletes with a moderate altitude to sleep at (1,700 - 2,700 m) whilst continuing to take part in their planned training sessions. The concept behind simultaneously training at sea level allows athletes to maintain their typical training intensities and inducing beneficial peripheral and neuromuscular adaptations. Typically, athletes will live in the altitude room for at least 4 weeks to reap the benefits. The competitive advantage our athletes gain from the live-high-train-low protocol may last up to 3 weeks after returning to living at normal oxygen levels.

Athletes are continuously monitored on a daily basis during their stay in the altitude rooms to ensure they are receiving an optimal dose. We can record any fluctuations in the oxygen content of the room (e.g. doors being opened etc). Heart rate and the concentration of oxygen in the blood is monitored indirectly using pulse oximetry whilst athletes are sleeping. Hydration status and hematological parameters such as red blood cell mass and haemoglobin content are assessed by regular blood test (see Figure 2.23 and 2.24). Furthermore, athletes will complete Acute Mountain Sickness questionnaires every morning. All of these parameters are carefully considered in the decision making process of whether to alter the oxygen content of the rooms or modify training volume or intensity.



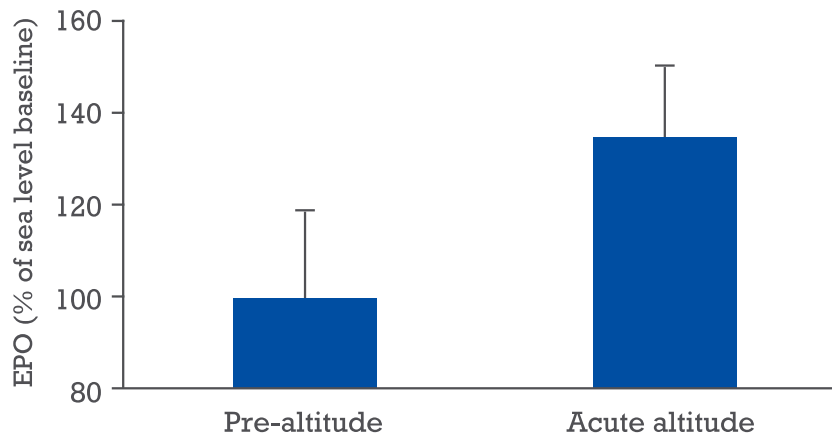


Figure 2.23 Increase in EPO production after 4 days of living at a simulated altitude of 1,700 m

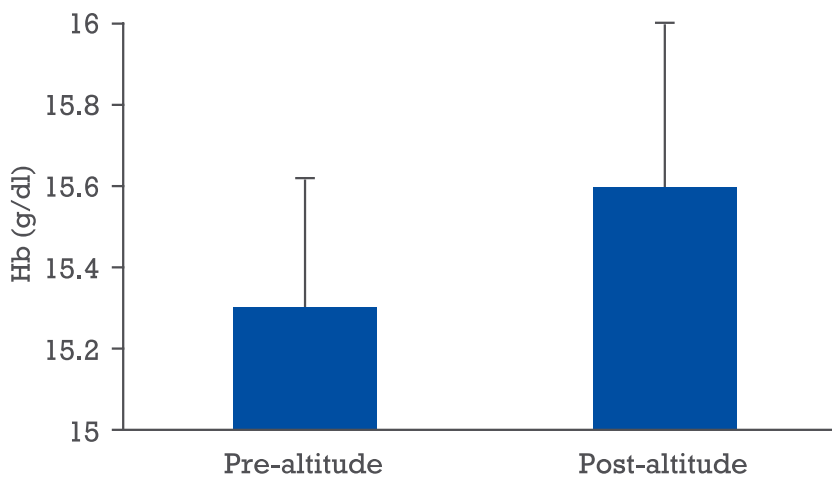


Figure 2.24 Increase in haemoglobin after 4 weeks of living at a simulated altitude (1,700-2,500 m)

- *Live-low-train-high*

When athletes get injured, sometimes they cannot participate in regular training activities. As an alternative, we can use the environmental chamber to simulate a high altitude environment and provide the athlete with increased physiological stress. High-intensity training at simulated altitudes has been shown to augment peripheral adaptations, such as improved oxidative enzyme activity, mitochondrial volume density and an increase in genes related to oxygen transport and utilisation. Determination of an appropriate hypoxic dose is critical to maximise training adaptation - as if it is too severe - the simulated altitude could impair training and exacerbate fatigue. This would compromise the quality of training and counteract the benefits derived from the greater physiological load. Optimal doses are likely to be individual (Table 2.4).

**Protocol** - 5 x 7 s sprint with 52 s recovery  
(x 3 sets with 6 min recovery between sets)  
**Altitude** - 3,800 m

|                           | Set 1  | Set 2  | Set 3  |
|---------------------------|--------|--------|--------|
| <b>Peak power (W)</b>     | 908    | 1027   | 949    |
| <b>Average mean power</b> | 626    | 639    | 603    |
| <b>Total work (J)</b>     | 21,091 | 21,601 | 20,359 |
| <b>Lactate (mmol/L)</b>   | 9.49   | 11.17  | 13.37  |

Table 2.4 Dose response to altitude training



Figure 2.25 Simulated altitude training in environmental chamber

## 2.2 On field support, regular training and monitoring

### Cardiovascular system training

#### Aerobic endurance training

The procedures of running on a treadmill are similar to those mentioned before in the section “Assessment of aerobic capacity”. If the  $VO_{2max}$  test result of the athlete shows that he has to improve his cardiopulmonary system, a training program focusing on improving aerobic capacity will be designed. The heart rate at aerobic and anaerobic thresholds determined from the  $VO_{2max}$  test is used to decide the intensity of the training. The following is one of the examples of the initial programme:

#### Programme 1:

|                              |  |
|------------------------------|--|
| <b>Content:</b>              | 2 x 30 minutes, 8 minutes rest, twice a week   |
| <b>Equipment:</b>            | Treadmill or Track   |
| <b>Intensity:</b>            | HR at about 5-10 bpm under the determined AT HR, average HR around 150-169 bpm, male/female running speed at around 11-12.5 km/h, blood lactate at around 3mM  |
| <b>Treadmill gradient:</b>   | 1%   |
| <b>Intensity monitoring:</b> | The athletes’ HR is monitored in the first 10 minutes of the training to make sure the intensity is in the target zone (Figure 2.26 and Table 2.5). This aerobic training programme lasts for a month and an AT training session is added each week. |

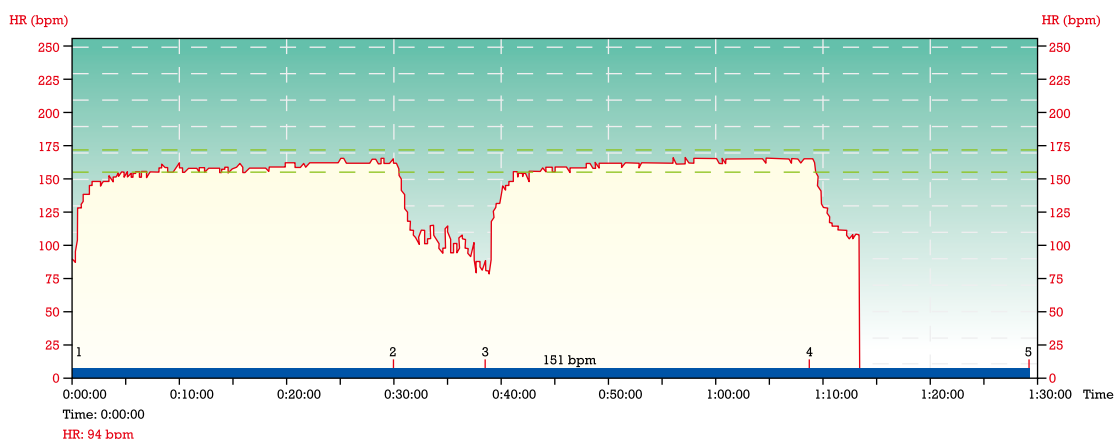


Figure 2.26 Heart rate data of 2 x 30 minutes run

|                              | Set 1 | Set 2 |
|------------------------------|-------|-------|
| <b>Speed (km/h)</b>          | 11.2  | 11.2  |
| <b>Gradient</b>              | 1%    | 1%    |
| <b>Max. Heart Rate (bpm)</b> | 165   | 168   |
| <b>Avg. Heart Rate (bpm)</b> | 158   | 160   |

Table 2.5 The Heart rate and running speed data of 2 x 30 minutes run

### Anaerobic threshold training (AT)

#### Programme 2:

|                              |   |
|------------------------------|---|
| <b>Content:</b>              | 2 x 15 minutes, 5 minutes rest, twice a week or<br>3 x 15 minutes, 5 minutes rest, twice a week   |
| <b>Equipment:</b>            | Treadmill   |
| <b>Intensity:</b>            | AT HR, average HR around 165-172 bpm, running speed for male around 13.5-14.5 km/h  |
| <b>Treadmill gradient:</b>   | 1%  |
| <b>Intensity monitoring:</b> | Blood lactate is measured after each set of 15 minutes running to control the intensity. Blood lactate should be maintained at around 4-5mM. Athletes' HR is monitored within each set of running to ensure the intensity is maintained in the target zone (Figure 2.27 and Table 2.6). |

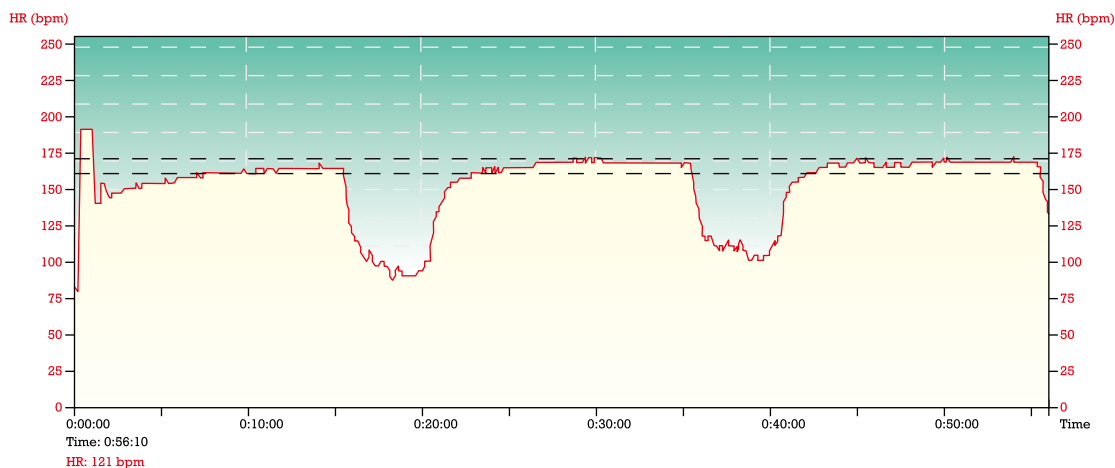


Figure 2.27 Heart rate data of AT training (3 x 15 minutes run)

|                        | Set 1 | Set 2 | Set 3 |
|------------------------|-------|-------|-------|
| Speed (km/h)           | 13.4  | 13.4  | 13.4  |
| Gradient               | 1%    | 1%    | 1%    |
| Max. Heart rate (bpm)  | 169   | 172   | 172   |
| Avg. Heart rate (bpm)  | 156   | 164   | 165   |
| Blood Lactate (mmol/L) | 4.68  | 4.54  | 4.68  |

Table 2.6 The heart rate, blood lactate and speed of AT training (3 x 15 minutes run)

### Speed endurance training

Depending on the needs of individuals, a speed endurance programme is designed for athletes to train their endurance using high intensity exercise. Its purpose is to lengthen exercise time before fatigue. Here is the sample speed endurance training programme for a squash players:

### Programme 3:

|                              |   |
|------------------------------|---|
| <b>Content:</b>              | 7 x 2 minutes, 2-3 minutes rest, twice a week, increase number of sets and gradient after the athlete has adapted to the training load  |
| <b>Equipment:</b>            | Treadmill   |
| <b>Intensity:</b>            | HR 5-10 bpm above the individual AT HR  |
| <b>Treadmill gradient:</b>   | 5%  |
| <b>Intensity monitoring:</b> | HR is recorded for the whole session and blood lactate is measured for the 4 <sup>th</sup> - 7 <sup>th</sup> sets of exercise. Lactate level should be around 8-14mM (Figure 2.28 and Table 2.7). |

*Note: Athletes should warm up adequately before having such a high intensity exercise. The trainer should observe carefully the physiological condition of athletes and give them encouragement but should not let athletes fall off from the treadmill.*

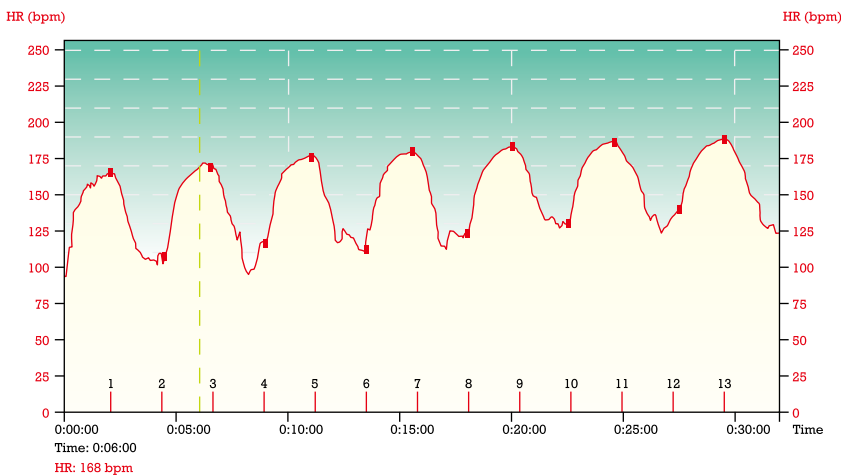


Figure 2.28 The heart rate data of 7 x 2 minutes run

|                                | Set 1 | Set 2 | Set 3 | Set 4 | Set 5 | Set 6 | Set 7 |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|
| <b>Speed (km/h)</b>            | 15.8  | 15.8  | 15.8  | 15.8  | 15.8  | 15.8  | 15.8  |
| <b>Gradient</b>                | 1%    | 2%    | 3%    | 4%    | 5%    | 6%    | 7%    |
| <b>Max. Heart rate (bpm)</b>   | 166   | 172   | 177   | 180   | 184   | 187   | 189   |
| <b>Blood lactate (mmol/L)</b>  | --    | --    | --    | 8.5   | 10.1  | 12.1  | 14.5  |
| <b>RPE</b>                     | 13    | 14    | 15    | 16    | 18    | 19    | 20    |
| <b>Rest between Set (Mins)</b> | 2'30" | 2'30" | 2'30" | 2'30" | 2'30" | 3     | --    |

Table 2.7 The training monitoring of 7 x 2 minutes speed endurance training

## EQUIPMENT INVENTORY

| Equipment                               | Brand & Model   | Quantity | Purpose of use   |
|---|---|----------|--|
| Isokinetic training and testing system  | Biodex system 3 PRO isokinetic system                               | 1 set    | The system allows training and testing on all the peripheral joints and isolate muscle groups at a constant speed. The feedback system allows evaluation of torque production at different movement angle, which provides objective data of neuromuscular control and strength to clinician and physiologists for preseason screening, injury prevention and athletic performance enhancement.                           |
|   | CSMI Humac system   | 1 set    |  |
| Laboratory treadmill                    | Retrofitting Giant Treadmill Saturn 300/125 r with speed of 80 km/h | 1 set    | The laboratory treadmill is customised with an oversized reinforced belt which can accommodate sprinting, cycling and is also suitable for wheelchair use. The highest possible speed of the treadmill is 80km/h. To ensure safety, athletes have to wear safety harness connected to safety stop.   |
| Cardiopulmonary exercise testing system | MedGraphics Ultima CPX Cardiorespiratory exercise system            | 1 set    | The system measures pulmonary gas exchange of athletes using breath-by-breath technique during exercise testing, which provides important physiological parameters, such as heart rate, blood pressure, oxygen intake (VO <sub>2</sub> ), carbon dioxide expired(VCO <sub>2</sub> ) and breathing rate. It has stationary and portable version which allow measurement during both laboratory-base and on-field testing. |
|   | Portable metabolic Cart (Cortex Metamax 3B)                         | 1 set    |  |
| Environmental chamber                   | Environmental Chamber: Welltech                                     | 1 set    | The chamber simulates different environmental conditions by pre-set temperature, altitude, humidity, which allows athletes to acclimatise to extreme environment before they actually travel to other part of the world for training or competition. It can also be used to assess physiological changes of athletes at desired conditions.  |
| Heart rate monitoring system            | Polar TEAM2 Pro   | 1 set    | The system allows real time heart rate monitoring, exercise intensity for a group of athletes wearing wireless heart rate sensor on chest straps. Full set of heart rate data is also recorded for post-training analysis.   |
|   | Polar TEAM  | 1 set    |  |

## SCIENTIFIC CONDITIONING CENTRE

| Equipment                             | Brand & Model   | Quantity | Purpose of use   |
|---------------------------------------|---|----------|--|
| Surface electromyography (EMG) system | Noraxon TeleMyo DTS 2400 T telemetry 16-channel EMG system  | 1 set    | The system measures the electrical activity of muscles by attaching electrodes on the muscle belly. It measures muscle activation sequence, rate of activation and amplitude, which are useful in athletes' comparison of their techniques before and after fatigue.   |
| Cycling ergometer                     | Wattbike Pro  | 1 set    | It comes with adjustable crank length, saddle and handlebar position, athletes can perform tests with the same setting as on their own bike. It offers a wide range of modes of operation, including isokinetic mode, fixed power mode and fixed load mode, which suit the needs in different training or testing. Parameters such as cadence, power, peak torque and heart rate are available for post-training evaluation. Some ergometers are integrated with power and torque analysis system for detail analysis of athlete's performance during time-trial or maximal power output test. |
|                                       | Wattbike Trainer  | 1 set    |  |
|                                       | Cylcus 2 ergometer  | 1 set    |  |
|                                       | SRM High Performance Ergometer with SRM Torque Analysis system  | 1 set    |  |
|                                       | Lode BV Excalibur   | 1 set    |  |
| Lactate and glucose analyzers         | Nova Lactate Plus   | 6 units  | The analyzers can process a small amount of blood sample for lactate and glucose value. These values are important indicators of exercise intensities, therefore allows coaches to fine tune athletes' training programme. The stationary and portable version allows testing and training in both laboratory-based and on-field environment.  |
|                                       | EKF Diagnostics Biosen C-Line Clinic Analyzer series (Glucose and lactate analyzer)                               | 3 sets   |  |
| Core temperature system               | HQ Inc. wireless core body temperature monitoring data recorder, CorTemp® ingestible core body temperature sensor | 1 set    | The system allows wireless detection of core body temperature by athletes taking a pill-sized ingestible thermosensor. It is a useful parameter for the prevention of heat-related illness.  |
| Portable altitude training system     | Altitude technology Solutions , model: ATS-HP   | 1 set    | The system simulates different altitude by reducing oxygen content through a breathing mask, which allows athletes to acclimatise before travelling to high altitude. It is relatively portable and can be used during exercise.   |
| Hypoxic sleeping room                 | Welltech altitude Training system, model: HS-500  | 2 sets   | The rooms are located in the athletes' hostel, which simulate high altitude by reducing oxygen content. It allows athletes to undergo live-high-train-low training protocol.   |



| Equipment   | Brand & Model   | Quantity | Purpose of use  |
|---|---|----------|---|
| Hyperbaric chamber                                      | Hearmec Hyperbaric oxygen capsule, model : O2 Prime OX-II     | 1 set    | The chamber supplies high oxygen content and high pressure for speedy recovery. With exposure to hyperbaric hyperoxic therapy, oxygen can be delivered to injured tissue in a more effective way to promote healing and recovery. The stationary chamber allows laboratory usages with maximum pressure at 50kpa, while the portable version can be brought to overseas training camps or competitions. |
| Spirometry testing system                               | Portable spirometer, model: Microlab 36-ML3500-STK            | 1 set    | The system measures lung function by the volume and speed of inhale and exhale air flow. The system is commonly used to diagnose asthma, chronic obstructive pulmonary disease and other conditions that affect breathing.  |
| Inspiratory muscle strength training and testing system | POWERbreath K5  | 1 unit   | The system measures the inspiratory muscle strength and power at different resistance. It also serves as a training device to strengthen the inspiratory muscle.  |
|   | POWERbreath Ironman Plus Heavy resistance inspiratory trainer | 2 units  |   |
| Pulse oximeter  | Nonin Wristox Model 3150 SK Pulse oximeter                    | 2 units  | The oximeter measures the oxygen saturation level (SpO <sub>2</sub> ) in the blood at rest or during exercise accurately. It detects the pulse rate and the blood oxygen level by infrared sensor on fingertip. Good blood oxygen level ensures adequate oxygen supply to muscle for exercise.  |
|   | Nonin Wristox 3100 pulse oximeter                             | 1 unit   |   |
| Global positioning system (GPS)                         | GPSports system WisPI system                                  | 1 set    | The system records the position data of athletes by wearing a handy sensor near the chest. It allows coaches to analysis session load for athletes and tactics for the entire team. The system is also suitable for outdoor endurance sports as it records speed and distanced covered.   |
| Cold compression therapy system                         | Game ready, model: GRPro 2.1                                  | 2 sets   | The system circulates ice water and delivers intermittent compression through specific wraps to reduce pain and swelling. It allows easy monitoring and adjustment of pressure, temperature, and treatment duration.  |
| Resting electrocardiography (ECG) system                | Philips Trim II ECG machine                                   | 1 set    | The system checks the heart's electrical activity through ten non-invasive electrodes when the subject is at rest. It detects heart activities as well as various abnormalities of heart rhythm.  |

## 2.B Strength and Conditioning

The goal of the strength and conditioning professional is to help athletes achieve their maximal physical performance potential without incurring injury. The nature of every sport is different as far as tactical, technical, as well as physical requirements. With regards to the designing of training programmes, there is not one recipe for all sports, nor is there one programme for any particular sport or individual, as individuals playing the same sport can also vary greatly. Many coaches and athletes often inquire about the best strength and conditioning programme for their sport, but the first answer to their question is usually the same. While there are training programmes suitable to meet the needs of most athletes in a certain sport, it would be dangerous and ineffective to apply a blanket training programme to athletes at the elite level. Much more investigation about the athlete's personal abilities, sport experience, injury history, physical qualities, and task-specific needs is a first step.

Designing an optimal strength training programme requires knowledge and information from many sources. Understanding the individual athlete generally requires a multi-disciplinary approach. That is, the coach's feedback, preliminary health screening information from sports medicine, various testing from sports science, nutrition input, and a psychological profile of the athlete from the sports psychologists. Armed with this information, the strength and conditioning professional must then have a good understanding of the sport he/she is working with from a physical perspective in terms of energy system requirements, body biomechanics, and specific movement needs. The information from sports medicine and sports science provides information about the individual's particular physical strengths and weaknesses and this is then compared with the requirements of the sport. In this way, we can improve our chances of developing the most effective training programme for the athletes, taking into account his/her individual physical attributes or limitations.

Strength and conditioning covers both the physical strengthening of athletes through various modalities of resistance training as well as designing and applying programmes to improve the physical conditioning of the athlete in terms of aerobic and anaerobic conditioning, agility, speed, and quickness. As the field of strength and conditioning may in some ways be broad and cover many aspects of physical training, the scope of the following pages will focus more on the training programmes of some special groups including recommendations for training of youth athletes, in addition to strength training for endurance athletes and for athletes of power and speed sports.

## SERVICE PROVISION

### 1 Designing resistance training programmes

The first step in a programme design is to perform a needs analysis. This process includes an evaluation of the requirements and particular characteristics of the sport and an assessment of the individual athlete. Evaluation of the sport can be achieved in a number of ways including literature research, observation, input from coaches, or visual feedback from video recordings (or high speed cameras if greater detail is required). The sport evaluation will include a movement analysis, a physiological analysis, and an injury analysis. For many of the common sports, such analyses are not necessary as much information already exists in the literature.

The second step is to make a profile of the athlete's needs and goals by evaluating training and injury status and also conducting a number of tests (maximal or submaximal strength and/or muscle endurance tests), analysing the results and then determining the primary goal of the athlete. Through testing it often becomes apparent that due to underlying weaknesses and imbalances, the initially desired goal of the coach or athlete may need to be postponed. Faulty body mechanics and muscle imbalances will lead to future injuries, so due attention must be given to these areas as a priority.

#### 1.1 Strength training in endurance sports

Athletic movements that utilise large muscle groups and need to be sustained for at least two minutes in duration are generally considered to be under the domain of endurance sports. Examples include rowing, triathlon, marathon, and road race cycling.

To excel in endurance events, the athlete needs a high level of maximal aerobic capacity ( $VO_{2max}$ ) and lactate threshold, good economy of movement and optimal levels of muscle endurance, and to some degree that of strength and power, in particular when it comes to the starts and finishes of races.

For many years, strength training was not popular among endurance athletes. The demands and adaptations to strength training and endurance training are on two extremes of the spectrum. It is/was commonly thought among practitioners of endurance sports that training for both strength and endurance has a cancellation effect on each other. Strength training stimulates increases in muscle fiber size, decreases capillary density, and decreases mitochondrial volume. In contrast, endurance training stimulates increase in capillary density, increases mitochondrial volume and leads to a decrease in muscle fiber size. Research on simultaneous strength training and endurance training has been mixed but it appears that concurrent strength and endurance training has no adverse effect on development of aerobic capacity, but only hinders gains in maximal strength and power. This finding is very important for the endurance athlete, as it was once thought that doing weight training would reduce Max  $VO_2$ .

Benefits of strength training include increases in strength of muscles and connective tissues (like tendons, ligament and bones). This helps decrease the risk of injury. Reducing injury risk is one of the most important factors for endurance athletes. Furthermore, recent studies indicate that strength training improves running economy, thus enhancing sports performance. Nowadays, more endurance athletes accept the idea that strength training is good for their sport and incorporate strength training into their training programme.

It is also important to note that strength training does not only include the use of barbells, dumbbells and weight stack machines. Other equipment may also be used such as medicine balls, Swiss balls, or performing uphill or downhill runs or bike, or resisted or assisted swims and other physical activities using some form of resistance (or assistance).

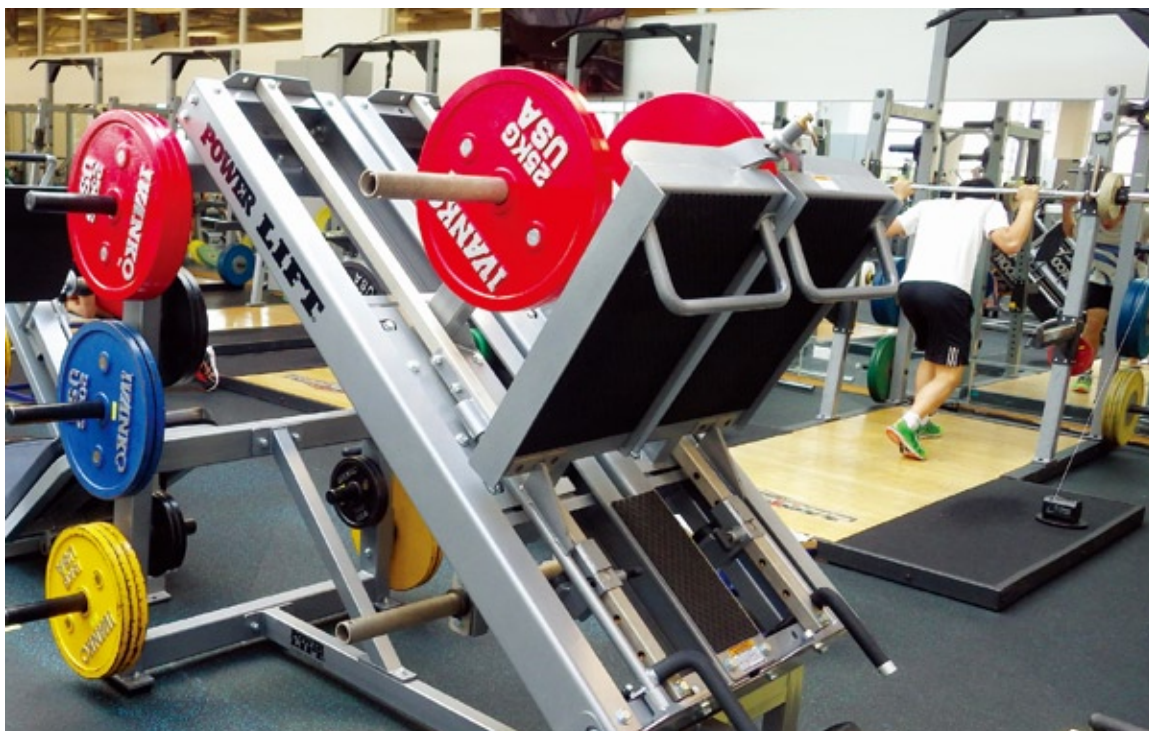


Figure 2.29 Bi/Uni Lateral LegPress

## 1.2 Training recommendations

- Assess the athlete's individual needs and goals. Pinpoint weaknesses and give these areas first priority for strengthening. If an athlete needs more muscle strength and power, then the strength training programme needs to be given priority to the endurance training of the sport. However, it is more common that an endurance athlete puts priority into training that improves aerobic capacity and the strength training programme would then be less frequent and more of a maintenance in injury prevention programme.
- Strengthen the major muscles in the upper and lower body including the core musculature (i.e. that of the abdominal and lower back regions).

- Progress gradually by increasing the level of difficulty or intensity while decreasing volume. Start from general strength exercises (like leg press or squat) and progress to more sport-specific movements (like 1-leg squat, 1-leg hops, swim bench). Movement speed should progress from slow speed to fast speed. Plyometric exercises and uphill runs are preferably used to increase muscle power.
- Gradually lessen strength-training sessions and include more specific exercise movements towards the latter part of the cycle and allow more time to focus on sport skills.
- Include rest days or weeks and light sessions for recovery from intense training. This is also seen in tapering, or the lowering of training volume while maintaining the intensity of training sessions. Tapering is emphasised about a week or two before a major race or competition.
- Complement other training programmes. Coordinate strength training with other parts of the conditioning programme (like prehabilitation/rehabilitation, flexibility, cardiovascular endurance or mental training). Strength training should not take away time from beneficial sport-specific work by including activities that will not help and may even hinder performance development.
- Maintain a training log to monitor response and adaptation to training.
- Periodisation – manipulate volume and intensity systematically in a strength training cycle to facilitate optimum effects from the programme. Athletes may start building up aerobic capacity in the off-season, then develop muscle strength in the early pre-season (high-resistance, slow-speed), followed by exercises and drills developing power in the late pre-season (low-resistance, high-speed) like plyometrics and high intensity interval training. Preventive or rehabilitative exercises are preferably performed throughout the year.

| Season     | Phase                 | Goal                               | Load (% 1RM) | Sets | Reps  | Rest       | Speed            |
|------------|-----------------------|------------------------------------|--------------|------|-------|------------|------------------|
| Off Season | Base period           | Prepare body for harder work ahead | 65-85        | 2-3  | 6-15  | 30-90 sec. | Slow             |
| Pre-season | Strength phase        | Develop maximum strength           | ≥ 85*        | 3-5  | 3-8   | 2-5 min.   | Slow to moderate |
|            | Power phase           | Improve power                      | 45-75        | 3-5  | 8-15  | 2-5 min.   | Fast             |
|            | Endurance             | Improve muscular endurance         | 30-50        | 2-4  | 40-60 | ≤ 35 sec.  | Moderate         |
| In-season  | Maintenance phase**   | Maintain power and/or endurance    |              |      |       |            |                  |
|            | Power maintenance     | Maintain power                     | 45-75        | 1-3  | 8-15  | 2-5 min.   | Moderate to fast |
|            | Endurance maintenance | Maintain endurance                 | 40-60        | 1-2  | 40-60 | ≤ 35 sec.  | Moderate         |

*Table 2.8 Sample strength training periodisation for endurance sports*

\* Load applies to primary or complex exercises (e.g. Squat, Bench press). Assistance exercises (e.g. Arm Curl, Leg Extension) should be limited up to 80% of 1 RM.

\*\* May alternate power maintenance phase with endurance maintenance phase.



## CASE STUDIES

A lightweight rowing athlete presented a bodyweight of 75 kg, which was still 3kg above his required 72 kg competition weight. As improper dieting would lead to loss in bodyweight with concomitant loss in lean body tissue, a proper nutrition programme had to be included along with his training programme. Muscle reduction for this athlete had to be minimised, as loss in lean body tissue would also lead to losses in power and strength.

The first step in our process was to sit down with the relevant parties, which included representatives from sports physiology, sports nutrition, sports psychology, strength and conditioning, the sport coach, and sports medicine. It was determined through this interaction that before establishing the most suitable programme for this athlete we initially needed the athlete undergo a nutritional and body fat assessment, responsibilities falling under the domain of the sports nutritionist. Body fat was measured at approximately 9% using a skinfold formula. There was some room for reduction in body fat, but we had to make sure that weight losses came primarily from fat and not from muscle and water only.

As lightweight rowers have restrictions for their maximal weight, it was important to design a strength training programme which allowed the athlete to get stronger but have minimal effects on muscle hypertrophy. Therefore, in the off season, we focused on strength and power training as opposed to muscle endurance or hypertrophy training. We had the rower train within ranges of 4-6 RM for 3-4 sets, which brought about improvements in strength with only minor increases in muscle mass. The training programme concentrated on rowing specific muscles such as legs, back, and arms. Most of the primary movements in the training were done with multi-joint exercises such as power clean, power pulls, dead lifts, squats, leg press, bench pulls, and chin ups. Special focus was also given to the trunk region, as it has been shown that a strong trunk musculature will provide a strong link in the kinetic chain between the arms and legs, and it will also decrease the chances of injuries.

We found that training was best arranged in the late morning, so as not to hinder afternoon technical training. If any aerobic exercises were included within the weight training session, it should come at the end. Preferably, however, 2-3 hours rest was allowed between sessions to allow for adequate recovery.

Competition rowing is primarily aerobic in nature, but as mentioned above, the inclusion of resistance training should not hinder the development of the aerobic system.

While carrying out all resistance training in a sports specific manner, such as adding resistance to the boat, may lead to some degree of strength gains for the rower, such practice on a regular basis may not be advisable because the

inherently awkward and unsafe flexed position of the spine during rowing should not be continuously overloaded for extended periods of time. When athletes become tired, they will compensate their technique and injury will occur. If sports specific strengthening is used, it is more advisable to add this type of training in a progressive manner or preferably on a rowing ergometer, as the loading can be fixed and the tendency for slippage of the oar in the water as a result of faulty blade work will not happen.

As the rower progressed through the programme, his weight was checked each morning upon waking up. His body fat measurement was reassessed every two weeks and diet carefully scrutinised. He was also monitored on a daily basis in training and had follow up ergometer tests every two weeks in the lab to make sure he was not dropping in power output due to reduction in bodyweight. Strength was not measured via testing, but rather regular monitoring during the training programme, as testing required too much of the athletes' time and was not seen as necessary.

Within two months the athlete was able to reach his competition weight, reducing body fat to approximately 6-7%. There may have been slight decrease in muscle mass as well, but as a result of the training programme, there were still increases in overall strength and endurance.

## 2 Training for speed and agility

### 2.1 Introduction to speed and agility

Speed is a major factor in explosive sports (sprinting, jumping, striking). It is also important in sports that require a quick response to different situations (team sports, racket sports). Its impact is further reduced in endurance sports (marathon, road cycling).

In a sport such as sprinting, which is performed linearly, i.e. from point A to point B only, it is important to achieve and maintain maximum speed for as long as possible. However, in most team and racket sports, in addition to speed, it is just as important to have agility. Speed is defined as the ability to perform a movement quickly, while agility pertains to the ability to stop and go quickly while changing directions, maintaining good balance when shifting your center of mass.

Training for speed and agility make use of the anaerobic (no oxygen) alactic acid (no lactic acid) systems, or the phosphagen system. These programmes usually involve maximal intensity efforts of less than 10 seconds with almost complete recovery in between so that lactic acid does not accumulate. Training modalities to improve speed and agility include strength-training, plyometrics, movement coordination drills, as well as drills for improving form and technique. Exact training will be based on the specific skills required for the sport.

### Definition of terms

|                        |   |
|------------------------|---|
| <b>Speed</b>           | Speed is the ability to perform movement quickly. This is important in sprinters, platform or springboard divers or table tennis athletes.  |
| <b>Agility</b>         | Agility is the ability to explosively stop, change direction and accelerate again. This is seen in team sports like basketball, water polo, and racket sports like tennis.  |
| <b>Speed-strength</b>  | The maximal force that can be developed rapidly at high speed. This is power at very fast speed, i.e., movements like hitting a baseball, jumping for a volleyball block or avoiding a blow. Training for speed-strength will require maximal efforts with lighter loads of approximately 40%RM. If the weights are too light, then the ability to produce power will be diminished and it will be a pure speed, rather than speed-strength exercise. |
| <b>Acceleration</b>    | Acceleration is the ability to achieve maximum speed quickly.   |
| <b>Speed-endurance</b> | Speed-endurance is the ability to provide energy for maximal acceleration or speed, and during repeated efforts of maximal intensity activities. An athlete with good speed-endurance will be less likely to slow down late in the game or after a sprint, as this ability will delay the onset of fatigue. Examples of activities include repeated fast-breaks in basketball, prolonged rallies in badminton or squash, and rowing.                  |

## 2.2 Methods used in training for speed and agility

Developing speed and agility is specific to the demands of the sport. In some sports, the maximum sprint speed is never reached like basketball and squash. For this reason, attention should not be focused on speed alone, but rather on other skills like agility, starting ability, acceleration, speed-strength (achieved through strength and power training), and speed-endurance.

### Strength and power training

Weight training with medium to heavy resistance, low repetitions and complete rest between sets is used to improve power or maximum force output. Many commonly used power exercises are derived from the Olympic lifts. These include such exercises as the high pulls, power cleans, or snatches. They are explosive actions involving multiple joints and muscle groups that are performed in a coordinated manner.

### Cleans

Plyometrics involve the stretch-shortening cycle that is seen in cocking of the arms and shoulder before hitting a tennis ball or throwing a punch. Examples of plyometric exercises include box jumps, bounding, depth jumps and medicine ball chest passes or overhead passes. These exercises help the muscle to reach maximal strength in a short time by storing energy in the muscles during the rapid lengthening (stretch) and immediately releasing the energy in the opposite direction (shortening). Plyometrics improves power as well as skills like agility, starting ability and acceleration.

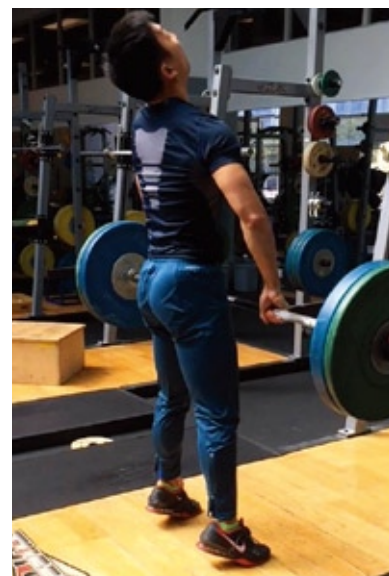


Figure 2.30 Second pull of the power clean

### *Movement drills*

Agility drills are exercises that include multidirectional movements with starts, stops, and rapid changes in directions. Sports-specific skills may also be incorporated in skills like passing or dribbling a ball (basketball) or adding a front kick (taekwondo). Examples are shuttle runs, ladder drills and sport specific plays in basketball.

### *Form and speed endurance*

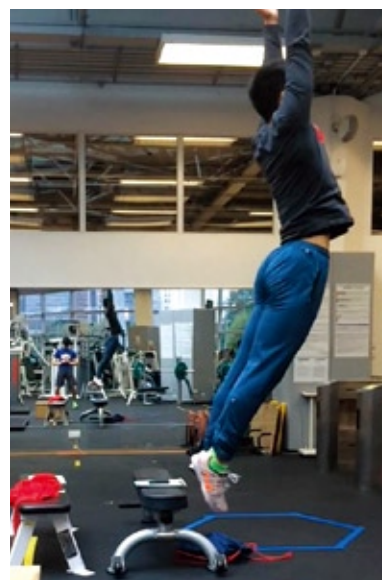
A sound technique is taught to the athlete early on using lower speed and intensity (approximately 75% maximum). Proper position of the body and the extremities is important to make movements more efficient and effective. For example, the position of the hand in relation to the forearm, arm and shoulders in the stroke mechanics of swimming. The intensity is gradually brought to 100% as techniques are mastered.

### *Other anaerobic training*

Methods used for speed-endurance training include interval training methods and repetition sprints. These activities involve maximal or near-maximal efforts that may last from 10 seconds to 3 minutes depending on the training goal. Recovery intervals, or the time between repetitions, are manipulated according to the goal. For example, when training the anaerobic alactic energy system, work intervals last from 10 to 60 seconds with complete recovery between repetitions, around 1-3 minutes rest intervals. Usually a work to rest ratio of about 1:4 or 1:5 is used.

Resisted loading is the addition of weight to either your bodyweight or the implement used in the sport. For example, wearing a weight vest during sprints, running uphill, and using heavier bats in baseball practices. The additional weight may range from 1 to 20 pounds.

Loading applies methods to artificially increase the speed of movement to improve stride frequency. These methods include downhill running, treadmill running or high speed towing. To achieve the appropriate training effects, proper mechanics of movement should be strictly maintained while using the resisted or assisted methods of training. Below are some general guidelines that should be considered when undertaking a speed and agility programme.



*Figure 2.31 Depth jump*



*Figure 2.32 Using Gymaware to monitor squat velocity*

## CASE STUDIES

A badminton coach presented a junior female athlete who he felt had good speed but was not able to change directions very well. As we had not worked with this athlete before, we consulted with the Sports Medicine Centre about her health profile to see if she had any underlying areas of injury or other concerns. The athlete's medical screening was normal, so we then inquired from Scientific Conditioning Centre (Scientific Assessment) whether this athlete had undergone any testing battery before. Since she had not, we needed to implement some basic tests to provide more information about her physical background.

We carried out a sprint test using electronic timing as well as a few agility tests and found that the coach was correct. The linear speed of the athlete was excellent among her peers, but her ability to change directions was not as good. She seemed to lack balance and strength, and possibly some coordination, when shifting bodyweight. The strength and conditioning coach then asked the sport coach to describe the athlete's training programme and what kind of exercises she has been doing to help the athlete improve agility.

Since the main focus of improving agility had been on-court training, this type of training may have overlooked the athlete's weak area, as the athlete may have compensated in other ways by adjusting technique and tactics. Agility is difficult to measure, because as a badminton player the variability in movements is immense. In order to get a closer look at the athlete's movement, the sports biomechanist was brought in to take some high speed videos. In contrast to those who 150 / 151 changed directions quickly and well, it seemed this athlete lacked strength in certain leg muscles. A full assessment of the athlete's leg strength was then carried out in the Sports Medicine Centre and the Scientific Conditioning Centre. Weak trunk muscles, poor unilateral balance, and weak leg external rotators and abductors were concluded. It also appeared that the athlete did in fact have weak posterior tibialis, which led to falling arches, femur internal rotation, and poor balance.

For the training programme, we would first work on bilateral strength of the legs and then shift to unilateral strength. At the same time the athlete worked on balance training with foam rubber pads and balance boards, and was asked to pay attention to the dropping of the arches at all times. At the same time low intensity (then building up to higher intensity) short bursts of direction change activities was recommended for on court training, paying special attention to proper body coordination and not allowing compensatory movements to occur.

This case was not a very difficult one and due to the young age of the athlete, she was able to quickly strengthen her weak areas and within 4-6 weeks was moving better than her peers.



### 3 Considerations for strength training in young athletes

The number of children participating in sports continues to grow. To be competitive, young athletes need to be physically fit and have high levels of sport skills.

Strength training is one way of improving a child's physical fitness. It is a method of conditioning designed to increase the ability to exert or resist force. Strength training uses a variety of equipment like body weight (push up, chin up), free weights (dumbbell, barbell) or weight machines (leg curl, lat pull).

Medical and health professionals agree that strength training can be beneficial and safe for both prepubescent and adolescents. Prepubescent refers to children between the period of infancy and adolescence. Adolescents refer to those that are between the period of childhood and adulthood where they start to develop the secondary sexual characteristics (e.g. pubic hair).

Strength training is distinct from weight lifting, power lifting or bodybuilding. Weight lifting is a competitive sport that involves maximum lifting (1RM) ability at higher speeds and a considerable level of skill is required. Olympic weightlifting includes the snatch and the clean and jerk. Power lifting is a competitive sport that also involves maximum lifting (1RM) ability at slower speeds and with heavier weights. It includes the deadlift, the squat, and the bench press. Furthermore, bodybuilding is a competitive sport in which muscle size, symmetry, and definition are judged, as opposed to lifting ability.

Strength training programme for young athletes may include the same exercises as those seen in weightlifting, powerlifting or bodybuilding but loads are submaximal (at most 80% 1RM).

#### 3.1 Benefits and risks

Recent studies have shown that injury risk is low and that properly designed and supervised strength training can increase muscle endurance and strength, strengthen bones, improve body composition and motor skills, protect against injury, and also have a positive psychological benefit for children. Most importantly, there appear to be no negative effects to the child's linear growth as a result of undergoing a strength programme.

Many fractures to the growth plate (area of developing tissue near the ends of long bones in children and adolescents) are caused by acute trauma (falls from a height, or blow to the body). Some are caused by repetitive use. However, such cases have not occurred in any prospective youth strength training study, which followed established strength training guidelines. In fact, resistance training may actually make bones stronger. Young athletes with hypertension may experience further elevation of blood pressure from isometric demands of the exercise.

*Definition of terms*

|   |   |
|---|---|
| <b>Resistance for strength training</b> | The use of progressive resistance methods (body weight, free weights, machines, etc.) to increase one’s ability to exert or resist force. |
| <b>Repetition</b>                       | One complete action of an exercise (up and down)  |
| <b>Set</b>                              | A group of repetitions separated by scheduled rest periods.   |
| <b>Rest/recovery</b>                    | The period of time taken between sets, between exercises or between sessions.   |
| <b>One Rep Max (1RM)</b>                | The maximum amount of weight that can be lifted once in good form.  |
| <b>Frequency</b>                        | The number of training sessions completed in a specified period of time.  |

**3.2 Safety considerations**

Safety is of utmost importance when considering resistance training for children, as careless and unsupervised training could lead to injury. Following are some important things to keep in mind. Follow established training principles (i.e., overload, recovery, specificity, etc.) and emphasise correct form and technique. More stress cannot be put on the point of correct form and technique. Many coaches, in an attempt to mimic the programmes of elite athletes, will overload their preadolescent athletes in hopes of achieving accelerated success. This is a formula for disaster. Not only must children train progressively, but also they must be mentally and emotionally ready to receive and follow instruction. Therefore, as a general rule, avoid heavy training loads (1 repetition maximum), ensure adequate rest, and provide qualified instruction and competent adult supervision. In addition to good supervision and sensible training methods, the exercise environment must be safe and free of hazards and equipment should be well maintained and properly sized to fit the young athletes. It is usually not recommended for preadolescents to do much lifting overhead. However, in cases where lifting a weight over the body, a spotter should be in position and should be able to communicate with the lifter. As a general guideline, the optimum ratio of supervisor to children is 1:10. All programmes should also include good warm-up and cool-down.

**3.3 Sample exercises**

Some of the sample exercises are dumbbell squats, lunges, dumbbell bench press, dumbbell rows, dumbbell curls, triceps push down, back extension, crunches, cross crunches. A properly designed and supervised strength training programme is now recognised as an important component of youth fitness programme, promotes health and may prevent sports injury provided that appropriate guidelines are followed.



*Figure 2.33 Dumbbell squat-start*



*Figure 2.34 Dumbbell squat-end*

### 3.4 Guidelines for youth strength training programmes

1. Recommend medical examination especially those who have known or suspected health problems.
2. The child should understand the benefits and risks associated with strength training.
3. Provide competent adult instruction and supervision.
4. Exercise environment should be free of hazards.
5. Include warm up and cool down.
6. Teachers and/or coaches should listen to each child's concerns and answer any questions.
7. Begin with 1 light set, 10-15 reps, 8-12 exercises that focus on the major muscle groups (lower body, upper body and core musculature – abdominal and lower back).
8. Depending on the individual's needs and goals, give 6-15 repetitions, 1-3 sets of a variety of exercises.
9. Start with a light weight when learning correct technique using controlled movements though the full range of motion.
10. Multi-joint exercises may be incorporated into the programme using appropriate loads and emphasising proper form.
11. Choose from a variety of strength training modes like: free weights (barbell, dumbbell), body weight exercises, weight machines, medicine balls, and stability balls.
12. Increase intensity gradually as strength improves.
13. Schedule 2-3 non-consecutive training sessions per week about 20-30 minutes per session.
14. Incorporate into overall conditioning programme (endurance, flexibility etc.) and practices with sports skills.
15. The resistance-training programme should be systematically varied throughout the year.
16. Encourage them to drink plenty of water before, during and after exercise.
17. Children should avoid competing against each other; instead they should be encouraged to feel good about their own success.



Figure 2.35 Hamstring stretch



Figure 2.36 MB chest pass

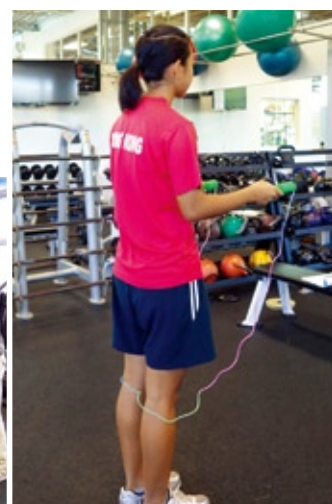


Figure 2.37 Skip rope

## CASE STUDIES

A group of young male tennis athletes between the ages of 9-12 were brought to the Scientific Conditioning Centre (Strength and Conditioning) for training. The coach felt that some systematic strengthening programme would be beneficial. In the desire to have athletes strengthen as rapidly as possible, young athletes are often started on weight training too soon and with loads that are too heavy. There are some downsides to doing this. Firstly, applying heavy loads too soon could result in undue injury. Secondly, young athletes that are still trying to gain a good grasp of their sports skills will often compensate their strength and/or stamina for lack of a good set of skills. As many coaches know, this leads to very adept junior athletes who will soon be overtaken by their peers that begin to focus on a systematic strengthening programme after they have mastered a good set of skills. This is quite noticeable when one considers how quickly a young female athlete will pick up a new technique while her male counterpart is still muscling his technique.

For these reasons, the strength and conditioning coach recommended that these tennis youngsters first learned to control their bodies and improve their strength initially with bodyweight alone. After carrying out some basic bodyweight tests, we found that the majority of these young athletes could not do a good set of proper push-ups but had already been doing exercises such as bench press, where entire body coordination and trunk strength are minimised. We also noted that the athletes presented very weak abdominal and lower back endurance when doing some basic clinical trunk endurance tests. We then planned a resistance training programme that used only bodyweight and medicine balls for a six-week period. We also decided that we would not advance the athletes to weight training until they could do a minimum of 10 (female) and 15 (male) proper push-ups and modified pull-ups, 60 no-load squats, and were able to reach above average level on the clinical trunk endurance tests.

After following the programme for eight weeks, all athletes achieved the minimal level to start their weight training programme. Since the athletes were still quite young, intensities were allowed no higher than 50-60 RM, and particular emphasis was put on proper technique. Large muscle group exercises made up the core of the training programme. These exercises were done primarily with free weight, as machines require less proprioceptive challenges, limit planes of motion, and are often not the right size for young athletes.

## 4 Post sports medicine advanced rehabilitation in Fitness Training Centre

To enhance optimum performance enhancement training of athletes, injury preventive exercises and strategies are included in the training programmes. Exercises are given to correct muscle weakness and imbalances, improve balance and proprioception, increase range of motion, increase muscle and soft tissue flexibility, and increase joint stability. The best strategy for rehabilitation may be to prevent the injury from occurring in the first place.

The Scientific Conditioning Centre (Strength and Conditioning) also helps injured and recovering athletes train so as to minimise the training time lost. When an athlete is injured and is undergoing rehabilitation by the Sports Medicine Centre, we are informed about the case and how it is being managed. Depending on the management and recommendations by the doctor, the athlete may continue strength and conditioning training without adding stress to the injured part. The athlete trains other body parts not injured or related to the injured part. This is to avoid significant detraining effects due to the usual rest that will be recommended.

After the athlete has gained functional capacity of the injured part, the Sports Medicine Centre refers the athlete for further advanced rehabilitation. This is rehabilitation training over and above the usual functional demand of the rehabilitated body part.

Emphasis will first be on the improvement of the proprioceptive sense of the injured part. This is done using different modalities that will challenge the sense of balance and proprioception. Balance boards, foam mats, stability balls and other equipment is used to train and develop the stability of the joints or body parts involved.

Training is coordinated with the Sports Medicine Centre, which gives some recommendations and/or restrictions for the training of the recovering athlete. Advance rehabilitation training programmes must be safe, challenging, multi-sensory approach, and sport action specific.

Coordination and cooperation with the coaches and the Sports Medicine Centre make it possible for the athlete to return to sport not only faster but safer as well.

## EQUIPMENT INVENTORY

| Equipment                                  | Brand & Model      | Quantity | Purpose of use   |
|--|--------------------|----------|--|
| Treadmill                                  | Precor             | 16       | Various cardiovascular training equipment, involving low impact or high impact movements, upper body, lower body or whole body, to develop athletes' energy systems. |
| Elliptical crosstrainer                    | Precor             | 5        |  |
| Adaptive Motion Trainer (AMT) crosstrainer | Precor             | 3        |  |
| Rowing ergometer                           | Concept II Model D | 30       |  |
| M3 spin bikes                              | Keiser             | 14       |  |
| Recumbent bikes                            | Matrix             | 4        |  |
| Upright bikes                              | Life Fitness       | 2        |  |
| Stepper                                    | Precor             | 4        |  |
| Stairclimber                               | Versaclimber       | 4        |  |



| Equipment                           | Brand & Model  | Quantity | Purpose of use   |
|-------------------------------------|--|----------|--|
| Seated upper body cycle             | Sci Fit Pro 2  | 2        | An upper body exerciser and lower body recumbent bike  |
| Windsurfing pumping machine         | Custom-made  | 2        | Specialised training equipment for windsurfing strength training and pumping technique.  |
| High speed treadmill                | Fitnex   | 1        | Smooth & powerful bicycle and wheelchair training treadmill with speed up to 60kph and -10% to 30% elevation.  |
| Manual treadmill                    | Woodway Curve  | 3        | Self-powered treadmill for high speed and interval work, as well as group training.  |
| Manual treadmill                    | Woodway Force  | 1        | Sport loading platform designed specifically for speed, acceleration, and athletic performance training  |
| Distance transducer                 | Fitness Technology Ballistic Measurement System with PT5A bar tracking transducer 400 Series Performance Force Plate System, Ballistic Braking System, Celesco/PT5A Portable Linear Position Transducer and Power Cage | 1        | For monitoring, providing feedback during training, and state-of-the-art assessment of human performance.  |
| Braking system                      |  | 1        |  |
| Force plate                         |  | 2        |  |
| Portable linear position transducer |  | 1        |  |
| Accelerograph transducer            | Gymaware   | 4        | Portable, accurate, versatile and easy to use device that measures power, velocity and other parameters during strength training movements and provides instant feedback.  |
| Accelerometer                       | Myotest  | 3        |  |
| Selectorised Machines               | Cybex  | Numerous | Weight training machines with stacks of weight plates adjusted by moving a pin. Resistance is applied in a guided or restricted manner. They are commonly used for upper body, lower body and midsection strength training.  |
|                                     | Matrix   |          |  |
|                                     | TuffStuff  |          |  |
|                                     | Precor   |          |  |
| Plate Loaded Machines               | Hammer   |          | Weight training machines that uses conventional weight plates as resistance. Resistance is applied in a guided or restricted manner. They are commonly used for upper body, lower body and midsection resistance training.   |
|                                     | Precor   |          |  |
|                                     | Cybex  |          |  |
| Pneumatic Machines                  | Keiser Air   |          | Pneumatic training machines that provide high resistance with very little inertia (moving mass), and without the dependence upon gravity while reducing the influence of momentum. Used for upper body, lower body and midsection functional, strength and power training. |

| Equipment   | Brand & Model  | Quantity | Purpose of use   |
|---|----------------|----------|--|
| Free Weights  | Eleiko         | Numerous | Applied resistance by use of a freely moving body. May be used to improve strength, local muscular endurance, explosiveness and power as well as core stability. |
| Olympic platforms 12, Benches & Racks, Half Racks and Power cages, Eleiko Olympic Bars and Competition Plates, Medicine Balls, Kettlebells, Powerbags, Training Ropes, Resistance Bands | Ivanko         |          |  |
|   | Hammer         |          |  |
|   | TuffStuff      |          |  |
|   | Precor         |          |  |
|   | Body Bar       |          |  |
|   | Hampton        |          |  |
|   | SPSS           |          |  |
|   | Powerbag       |          |  |
|   | Power System   |          |  |
|   | AOK            |          |  |
|   | New Nemo       |          |  |
|   | TRX            |          |  |
|   | First Place KB |          |  |
|   | Vertimax       |          |  |
| Theraband   |                |          |  |
| Perform Better Strengthband   |                |          |  |
| Balance   | Airex          | Numerous | Develops balance, motor coordination and core strength   |
| Wobble boards, Rocker boards, Balance boards, Bongo boards, Stability balls   | Fitter First   |          |  |
|   | AOK            |          |  |
|   | Bongo Boards   |          |  |
|   | BOSU           |          |  |
| Foam rollers  | Rumble Roller  | Numerous | For self-myofascial release, self-massage and stretching   |
|   | AOK            |          |  |

## 2.C Talent Identification and Development

Talent in sports is an extremely complex concept. An adolescent with athletic skill, passion, character, and the potential to progress to and remain at elite levels of performance is what can be called talent. Talent Identification refers to the process of recognising athletes with potential to excel in a particular sport or those currently involved in specific sport. Traditionally this depends upon experienced coaches screening talent through subjective assessment and competition results. Nowadays, Identification entails predicting performance over various periods of time by measuring physiological, psychological, and social qualities as well as an athlete's technical ability, either alone or in combination. Talent Development is a process whereby newly identified talent undergoes structured training and competition to confirm they possess the greatest degree of trainability and adaptability. In order to realise an athlete's potential, training covers physical conditioning, skills developments, technical and sport science knowledge development.

The Talent Identification and Development (TID) Unit is a unit within the Scientific Conditioning Centre which aims to verify, confirm and develop the next generation of elite athletes across all sports under the guidance of the HKSI. The TID Unit works closely with coaches and NSAs to understand their needs and tailor-make the most appropriate programme (including athlete education) to identify and support the next generation of talent.

The TID Programme is based on the FTEM (Foundation, Talent, Elite and Mastery) model of long-term athlete development and the underlying principle of biopsychosocial aspects of elite athlete development. The essence of FTEM is to create an environment that allows junior athletes to build a multi-disciplinary understanding of their talent, to retain and thereafter nurture them in the programme.

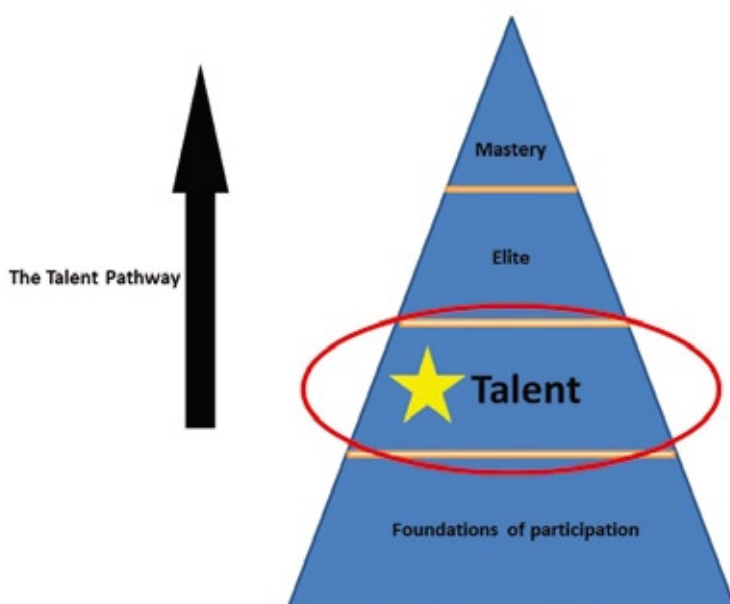


Figure 2.38 FTEM Model

The TID Programme mainly provides a centralised approach of support to add value to NSA's community-wide talent identification processes. It also funds follow up specialised programmes and inputs into the development of the "elite culture" among identified young athletes. The programme develops a database to establish scientific benchmarks and a fast track talent development process in parallel to the TID system.

## SERVICE PROVISION

### 1 Talent Testing Programme (TTP)

TTP protocols are used to assist in screening new recruits or identify junior athletes, who are already involved in a sport and have the potential for promotion to higher-level training squads or to enter the Sports Specific Talent Verification Programme.

This programme assesses physical attributes by way of dedicated assessment days and is made up of two parts. Firstly, the programme is designed to provide regular monitoring of an athlete's performance (already in junior programmes) and aims to build a database of Hong Kong athletes' physical attributes. Athletic attributes including endurance, agility, speed, strength, reaction time, and repeat sprint ability, nutritional behaviors, psychological make-up and skills associated with team-work and competition.

Secondly, one-off testing days screen talented athletes with the aim of verifying potential athletes for a particular sport and with the objective to support NSAs in their quest to find new talent or progress young athletes into the Talent Development Programme.



Figure 2.39 Torso pull test for swimmer



Figure 2.40 The rugby athletes are ready for yoyo test

## 2 Sports Specific Talent Verification Programme (SSTVP)

The HKSI provides technical support to NSAs in a 3-month talent verification programme. It includes testing (Pre & Post) and three months of sport specific skills and technical training. The SSTVP is designed to ascertain if those physically gifted athletes have the technical, emotional and tactical abilities of elite performers in a structured sports specific training environment.

The SSTVP supports sports and athletes in enlarging the number of talented athletes in NSAs and ultimately increase the elite athlete pipeline. This programme offers a chance to track and profile athletes at a young age through monitoring training, performance, progression and injury at this preliminary stage of a young athletes sporting career for future reference.

### CASE STUDIES

#### Rowing Talent Identification Day

The TID Unit co-organised the “Rowing Talent Identification Day” under the Sports Specific Talent Verification Programme with the Hong Kong Rowing Association (HKRA) in for verifying potential rowing talent in the community. 314 participants enrolled and a 4-hour testing programme was carried out.

56 participants were then selected to join the 3-month HKRA sports specific training. Upon completion of the training, a post talent identification test was conducted to evaluate their training progress and further verifying their talent.

11 rowers were then nominated to join the HKSI Potential Athletes group and complete a 1-year training and competition programme with the aim of finding athletes capable of joining the full time elite training senior squad.

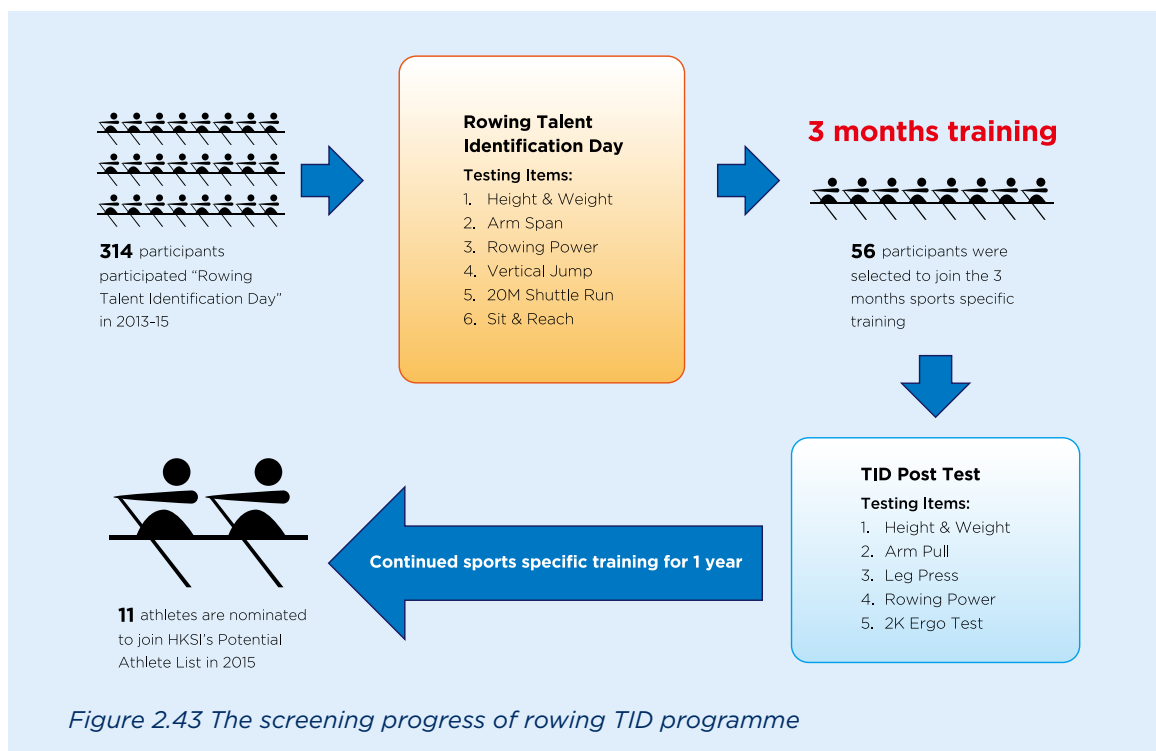


Figure 2.41 DYNOball test for rower



Figure 2.42 The rowers are conducting the 6m track power test





### 3 Talent Development Programme (TDP)

The TDP aims to support the develop of potential athletes by providing weekly classes for identified junior potential elite athletes over a yearlong 40 session training and education programme. The programme provides skills to enhance their personal competencies as elite athletes through self understanding, the setting up of long-, mid- and short-term goals and an in-depth understanding of the career challenges that a professional sportsperson encounters. It also shares knowledge of physical conditioning, sportsmanship, sports injury, biomechanics, physiology, nutrition and mental skills to complement their technical sports specific training.

Testing and evaluation are conducted on three occasions, pre-programme, mid-term (6<sup>th</sup> month) and post-programme (12<sup>th</sup> month). The aim being to track progression, introduce these young athletes to constant evaluation which forms part of a professional athlete's career and to enhance performance. Participants and guardians evaluated the programme and give their feedback as part of an open, transparent and outcome focused approach.

## CASE STUDIES

### Talent Development Programme for gymnastics, tenpin bowling and cycling athletes

53 athletes from Gymnastics, Tenpin Bowling and Cycling enrolled in the "Talent Development Programme" in 2016-17. Throughout the 40 weeks of strength and conditioning training and educating in sports science, athletes and coaches were positive the benefits helped deepen their knowledge and understanding of their sport in an all-encompassing manner as part of their sport specific skills development.

*Talent Development Programme includes the following 7 modules:*

1. Physical Fitness Assessment (2 sessions)
2. Sports Nutrition (2 sessions)
3. Sports Medicine Workshop (1 session)
4. Sports Psychology (2 sessions)
5. Adventure Training (2 sessions)
6. TID Testing (3 sessions)
7. Strength and Conditioning Training (32 sessions)

**• Talent Development Programme 2016-17 Course Outline:**

| Week  | Theme                                    | Content   |
|-------|--|---|
| 1     | Talent Identification Test (Baseline)    |   |
| 2     | Sports Medicine -Workshop                | Common gymnasts injuries & prevention                         |
| 3-6   | Strength and Conditioning Training       | Leg power & upper limb training                               |
| 7     | Sports Psychology - Lecture              | Stress  |
|       | Strength and Conditioning Training       | Agility & balance training                                    |
| 8     | Elite Athletes Essence                   | Team building Overnight Camp                                  |
| 9-13  | Strength and Conditioning Training       | Cardiovascular training                                       |
| 14    | Physical Fitness - Lecture               | Definition of physical fitness, Basic body structure          |
| 14-18 | Strength and Conditioning Training       | Agility & balance training                                    |
| 19    | Physical Fitness - Lecture               | Physical fitness and sports performance, Benefits of exercise |
| 19-21 | Strength and Conditioning Training       | Leg power & upper limb training                               |
| 22    | Talent Identification Test (Midterm)     |   |
| 23-27 | Strength and Conditioning Training       | Cardiovascular training                                       |
| 28    | Sports Nutrition - Lecture               | Weight management   |
| 28-33 | Strength and Conditioning Training       | Agility & balance training                                    |
| 34    | Sports Nutrition - Lecture               | Hydration in sports and exercise                              |
| 34-37 | Strength and Conditioning Training       | Leg power & upper limb training                               |
| 38    | Sports Psychology - Lecture              | Stress  |
|       | Strength and Conditioning Training       | Leg power & upper limb training                               |
| 39    | Talent Identification Test (Final)       |   |
| 40    | Elite Athletes Essence Cum Closing Party | Team building Day Camp  |



Figure 2.44 Adventure camp for Talent Development Programme 2016-17 athletes



Figure 2.45 Talent Development Programme pre-test for gymnasts



Figure 2.46 Sports medicine workshop



Figure 2.47 Strength and conditioning training



## 4 e-Platform

The TID Unit is establishing a secure online platform for athletes to view their training history and test results. A systematic recording system is beneficial and helpful for athletes as well as their coaches to exchange information and provide remote support.

## 5 Joint Talent Development Camp (JTDC)

The JTDC aims to enhance cultural exchange opportunities for talented young athletes from Hong Kong with overseas athletes. Several activities are organised throughout the development camp, such as sport-specific training, friendly competitions, sports science support, cross cultural exchange activities and sport education programmes delivered via Discovery Games. Many hours of technical sports specific training is carried out under the guidance of sports specific coaches from each country.



Figure 2.48 The Japanese and Hong Kong fencers are training together



Figure 2.49 A welcome dinner for Japan Sport Council youth athletes exchange tour

## EQUIPMENT INVENTORY

| Equipment                    | Brand & Model    | Quantity     | Purpose of use  |
|------------------------------|------------------|--------------|---|
| Body fat composition monitor | Tanita           | 2            | For weight and body fat measurement   |
| Laser rangefinder            | Bosch            | 1            | For distance measurement  |
| Portable stadiometer         | Seca             | 2            | For height measurement  |
| Y balance test kit           | Move2Perform     | 3            | For measuring pre and post rehabilitation performance, improvement after performance enhancement programmes, dynamic balance for fitness programmes, and return to activity readiness |
| Anthropometer                | Lafayette        | 1            | For measuring the dimensions of the human body  |
| Sit-and-reach box            | Gopher           | 3            | For flexibility of lower back and hamstring measurement   |
| Reaction time machine        | Beida Jade Bird  | 1            | For reaction time testing   |
| Digital grip dynamometer     | Takei            | 2            | For grip strength measurement   |
| Skinfold caliper             | Skyndex          | 2            | For skinfold thickness measurement  |
| Vertical jump tester         | Gopher           | 3            | For lower limb power measurement  |
| Stopwatch                    | Seiko            | 8            | For time measurement  |
| Stopwatch printer            | Seiko            | 1            | For time record printing  |
| Speed gate                   | Brower           | 3 pairs      | For sprint time measurement   |
| Speed gate & jump mat        | Swift Speedlight | 10 pairs & 2 | For sprint time, reaction time, jump height and power measurement   |
| Long jump mat                | APEX             | 2            | For board jump measurement  |
| Digital goniometer           | HALO             | 1            | For joint rotation measurement  |





# CHAPTER 3

## SPORT BIOMECHANICS & TECHNOLOGY CENTRE

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### Introduction

The Sport Biomechanics & Technology Centre is responsible for providing measurement and analysis of sporting skill and tactic. Then feedback will be given to coaches and athletes on technique and game improvement based on evidence. The Centre provides consultation and advice to different departments for setting up training assisted feedback systems on performance analysis in which uses the latest innovative video and computer-based technologies to examine and evaluate athletes' sport performance to enhance skill acquisition. In some cases, the available training and testing devices cannot fulfill the needs of the athletes and our coaches. The Centre will fabricate devices according to specific training and testing requirements.

The Centre works closely with the other centres to identify the physiological requirements of individual sport by means of on-field video analysis. The results will be shared with the strength and conditioning coaches for reference when preparing training plans.

## 3.A Sport Biomechanics

### SERVICE PROVISION

Biomechanics is the sport science field that applies the laws of mechanics and physics to human performance. Biomechanists study forces and the effects of those forces on and within the human body in sports-specific activities. Whenever a force is applied to the body, biomechanists can analyse and interpret its cause and effect. Resources used in the Centre included video feedback, 3-D motion analysis, high speed and underwater cameras, force platforms and speed gates or sports-specific analysis systems.

Motion analysis includes measurement of magnitude of motion, the timing of motion and the coordination of numerous body segments. The analysis can be used to monitor progress by tracking changes in performance related variables and can take place in a variety of settings such as the laboratory, during training or while the athlete is in competition. Then feedback is given to coaches and athletes by describing body segment movements over time.

Game analysis of filmed match content reveals trends and statistics that help coaches assess their player's performance, develop optimal strategies, and understand his/her opposition's strengths and weaknesses. In individual racing events, such as in swimming and athletics, races can be broken down into appropriate splits to help improve pacing strategies and identify phases of the race where an athlete is losing time.

Coaches utilise this process to compile objective and reliable feedback of performance that can be devised into developing performance plans, which has the ability to aid athletic performance. Information from motion and game analyses helps sports medicine and fitness professionals understand sporting movement patterns to minimise injury risks and design specific strength training program.

### CASE STUDIES

#### Power output monitoring in cycling

##### *Air resistance*

The major resistance in human-bike system is from air. Cyclist needs to have good technique to reduce the external resistance such as air resistance and energy consumption during the race to obtain good result. Power output of a cyclist is an important indicator on his/her

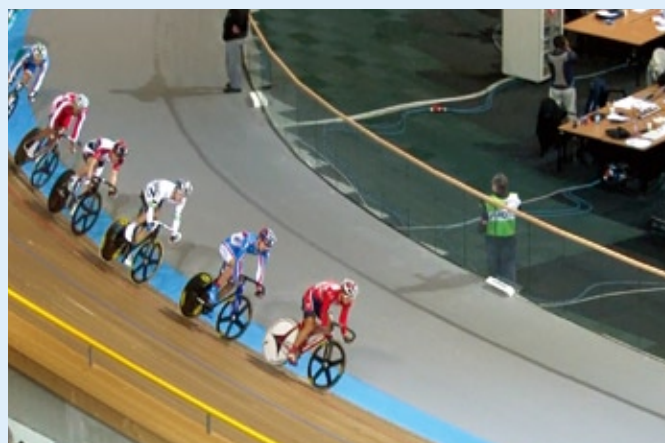


Figure 3.1 Cycling velodrome for track competition

ability to overcome the resistance. The competition duration is different in different events. The cyclist should maintain a reasonable high power output during the competition time.

### Method

The power data would be collected during competition or training. SRM system (Figure 3.2) is a sports specific device that installed onto the bike. The gear ratio would be selected to match with specific power in the event. The internal clock of powercontrol would be synchronised with the display clock of the video camera. This procedure could assist to identify the start and end positions of the analysis in SRM data. Power would be recorded by the SRM system during the cyclist performed on track (Figure 3.1). The data would be downloaded to the computer and the maximum and average power output could be determined with reference to the video footage.

### Power requirement

There is great difference in power requirement for cyclist in different events. For sprint event cyclists, the power is the specification factor that indicated their ability in the event. Their power is higher than the distance cyclists. For point race event, the cyclist should produce high power during the intermediate sprint in point awarding lap and lap gain. Point awarding lap should be run off every 6 laps or 10 laps in 333 m-and 250 m-tracks respectively so the high power requirement would happen in an interval manner. This kind of cyclist should have a basic aerobic power and the lower power than the sprint cyclist. In general, high power output of the cyclist could be found in the following conditions:

- point awarding lap and lap gain in point race of track cycling
- overtaking in road bike
- sprint to get a better position when they approach the finish line.



Figure 3.2 Powermeter (left) and powercontrol (right) of SRM system

By monitoring the power output of cyclist, the performance could be assessed.

### *Factors affecting the power output*

Factors such as track surface material, wind speed, temperature and gradient of track could not be taken into consideration in the test under laboratory condition. If the data is collected under competition environment, the effect of the above factors is one of the determinants to the result. Comparison should only be made under same environment such as same track and weather condition.

### *Power output of position exchange in team event*

In team event, the members of the team required to take up the leading and following positions one by one. They should have a good position exchange technique in this kind of team event. The leading skill is the same as individual technique. The control of bike distance of followers with front bike is important to reduce the air drag in following position. Each member in the team needs to change position every half of track distance ride. Position exchange includes leaving and joining the group. The skillful cyclist should not spent effort to complete the position exchange. For the following technique, the greater the power difference between the leading and following positions, the better the technique. This implies the power output is relatively small in following position and the follower could receive better recovery. On concrete track, the power in following position was found to be 70 - 75 % of leading position. On wooden track the following position was found to be 65 - 70 % of leading position. In position exchange, the power difference between leaving and joining the group should be as small as possible. Common mistake in cyclist is “over relax” in leaving the group and “too tense” in joining the group. For a good technique, the power in joining the group should be greater than leaving the group for 1.5 times. If this difference is greater than 2.5 times, the exchange technique will be classified as below average.

## Game analysis in table tennis

Table tennis is an open skills sport which involves a sensible use of tactics and skills in a match. The game analysis can break down a match into different isolated components of skills. Useful information can be extracted from the video footage to identify the frequency, such as, serve, receive, attack success, unforced error in the match. The analysis help reveal player's style. With reference to the data, specific training could be designed to improve player's skill.



Figure 3.3 Dartfish Team Pro analysis menu



A 50Hz digital video camera was used to capture the whole match in a competition. The video footage was processed by Dartfish Team Pro 7.0 to quantify the successful rate of different skills and tactic statistically (Figure 3.3). The type of skill included (1) serve and receive, (2) third stroke and (3) rally.

### Serve and receive

The players intended to have control on the game right after the serve or first return. The player was made use of the serve to make the return from opponent more controllable so that the player could easily return a short ball (ball land on table after re-bounce) to reduce the risk to be controlled by opponent. Summary of the game of the above technique such as technique distribution, successful rate and failure rate would be presented statistically.

### Third stroke

It was not easy to gain point in first two strokes. Third stroke was a crucial transition to a rally. There may have routine pattern on return path in some players. For example, European players would like to return a fast slant ball when they received a slant ball. The advantage of European was power with limited ball control technique. Also, the distance travel by ball was long and the rebound point was at far side of table. On the other hand, the Korean players would like to return a straight ball. Although it required better skill, small amount of power was required and it would be easier to force the opponent to lose the position.

### Rally

Both players needed to perform their best to resist the attack of the opponent when the athletes were playing in rally after the third stroke. The analysis would focus on the ball path, force & un-force success rate and force & un-force failure rate. The state of control for each failure should also be determined. The performance of the athletes could be statistically presented of the above parameters. In general, the winner would have a higher force success rate. So, higher force success rate implied the athlete was more skillful.

|           | Serve |      |             | Receive   |            |                   | Third stroke |      |                   | Rally            | Attack success | Unforced error | Net point |
|-----------|-------|------|-------------|-----------|------------|-------------------|--------------|------|-------------------|------------------|----------------|----------------|-----------|
|           | Short | Long | (Gain/loss) | Short     | Long       | Drive (Gain/loss) | Short        | Long | Drive (Gain/loss) | Nos. (Gain/loss) |                |                |           |
| Hong Kong | 20    | 19   | 0           | 7<br>(-6) | 26         | 8<br>(+3/-1)      | 0            | 7    | 16<br>(+5/-3)     | 17<br>(+4/-13)   | 12             | 23             | -11       |
| Country C | 4     | 39   | 0           | 3<br>(-1) | 17<br>(-1) | 18<br>(+5/-3)     | 0            | 6    | 24<br>(+6/-9)     | 20<br>(+10/-10)  | 21             | 24             | -3        |

+: point gain; -: point loss

Table 3.1 Sample statistical profile of the match between Hong Kong and Country C players

According to the tactics analysis statistics (Table 3.1), the ratio of long and short serves of Hong Kong player was 1 to 1. Also, he produced more receive errors (-7) than his opponent (-5). However, the successful rate of the drive of third stroke was reasonably high (+5/-3) and more effective than his opponent (+6/-9). It was also suggested that the Hong Kong player should reduce the chance of point loss in the rally (4 points gained and 13 points loss) so as to improve his overall performance in the match.

Statistical analysis of the serve, receive, third stroke and rally in the game could provide tactical pattern of both parties. This could assist the coaches to plan ahead on specific skill training on individual player.

## EQUIPMENT INVENTORY

| Equipment                           | Brand & Model                                   | Quantity | Purpose of use  |
|-------------------------------------|---|----------|---|
| Digital camera                      | Casio Exilim Pro EX-F1                          | 4        | Video capture   |
| Video camcorder                     | Sony HDR-XR550E                                 | 6        | Video capture   |
| Video camcorder                     | Sony HDR-CX900E                                 | 4        | Video capture for analysis software operated in MacBook |
| High speed video camera             | NAC Memrecam FX K4                              | 1        | Super slow motion video capture                         |
| Plasma TV set                       | 50" Panasonic TH-P50V10H                        | 1        | Presentation display to coaches and athletes            |
| Video-based motion analysis system  | Peak Motus v9.2.0                               | 1        | Movement analysis                                       |
| High speed motion analysis system   | Vicon T40                                       | 1        | 3-D movement analysis                                   |
| Video-based motion analysis system  | Dartfish TeamPro 7.0                            | 4        | 2-D movement analysis and game analysis                 |
| Video-based motion analysis system  | SportsCode Elite and Pro video analysis systems | 1        | Game analysis   |
| Triaxial accelerometer              | Dytran 3273A2                                   | 1        | Acceleration measurement                                |
| Wireless eye tracking system        | Ergoneers Dikablis                              | 1        | Point of gaze measurement                               |
| Multi-component force plate         | Kistler 9253A11                                 | 2        | Foot reaction force                                     |
| Multi-component force plate         | Kistler 9286B                                   | 2        | Foot reaction force                                     |
| Foot pressure measurement treadmill | Zebris FDM-T                                    | 1        | Gait pressure   |
| Insole pressure measurement system  | Novel Pedar                                     | 1        | Gait pressure   |
| Tension & compression load cell     | Futek Model LSB                                 | 3        | Tension force   |
| Sports radar gun                    | Stalker   | 1        | Object speed  |

## 3.B Sport Technology

### SERVICE PROVISION

A major trend in sports technology is toward real-time application of devices that provide athletes, coaches, and analysts with immediate feedback across a wide range of performance factors. The Centre will develop and fabricate devices that can monitor an athlete's physical, technical and tactical capabilities according to specific training and testing requirements.

Performance analysis has developed as a result of recent technological advances within the areas of IT, digital photography and video analysis software. It provides objective feedback to athletes and coaches through the use of video analysis, the compilation of CDs or DVDs and statistical information. It can be used during or after an event to quantify the athletes' performance in an accurate and reliable manner. Several in-house training video feedback systems were already installed inside the HKSI training venues to provide instant video feedback during the training session of the athletes. By looking at the playback, athletes can easily make modification of skill based on the coaches' advice.

### CASE STUDIES

#### Body orientation detection system

Racing in terms of speed, power, strength and strategy are the objectives in most of the sports. But sports like snooker, tenpin bowling and boccia required stable and consistence body movement. In addition to the sport performance, sport injury prevention is another topic, a scientific method to limit the range of movement could be a way to prevent injury from high risk movement, like weight lifting in strength training. Furthermore, sport medicine practitioner may need to know scientific assessment in terms of body segment movement to come up with a correct diagnosis or to monitor the recovery process. Although video or infra-red based 2-D/3-D motion capture analysis system is a kind of common system to measure segment movement, this new system is an alternative way to provide movement data with the following advantages 1) inexpensive hardware, 2) easy to setup, 3) less restriction on testing environment and 4) almost real time to provide data.

#### *Method*

A smart phone application for Android was prepared to make use of the various built-in motion sensors, including accelerometer, gyroscope, and magnetometer to collect orientation data. Furthermore, there was an interface for setting up range of motion alarm. Once the body segment was over the range of motion, an acoustic notification and device vibration would be provided. With respect to data real time feedback and visualization, the orientation data was transmitted to PC (via Bluetooth SPP generic profile) wirelessly. With the help of a USB webcam together, qualitative and quantitative instant feedback could be provided to coach and athletes.

### Personal computer interface

The software interface, shown in Figure 3.4, was written by “Processing2+” open source programming software. The interface provided body segment orientation diagram, acceleration and angular rate data which presented in rolling display format. A live video with numerical angle data were displayed at the top of right hand corner. A 3-D body segment orientation figure synchronized with the live video was illustrated at the left and the spatial orientation of the 3-D model could be freely changed by the user.

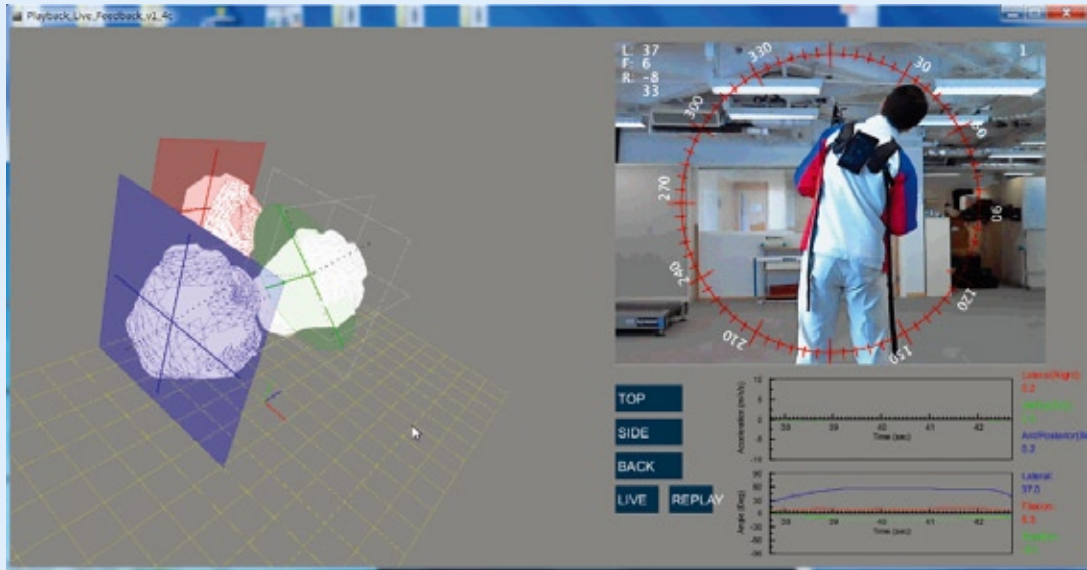


Figure 3.4 Data visualization on a user interface

### Mobile apps application

The apps main operation menu is shown in Figure 3.5 and provided numerical data, acoustic and vibration feedback to athlete. Lateral, flexion/extension and rotational angles of the body segment were displayed at the top left corner of the menu. A “Set Zero” button, located in the middle of the main screen, was used to get a reference orientation. Maximum and minimum angles could display right after the test.

Athlete could configure the range of motion limit by the “Set Range” button on the menu. An acoustic and vibration feedback would alert the athlete once the movement exceeded the allowable range of motion. The orientation data and acceleration data would record into the smart phone in comma separate values (CSV) format by pressing the “Record/Stop” button. The CSV file could be downloaded to PC and opened with almost all word processors, such as notepad and MS Excel. A VBA Excel was prepared to post process the data. The mobile device could be paired up with a personal computer for the purpose of data communication.

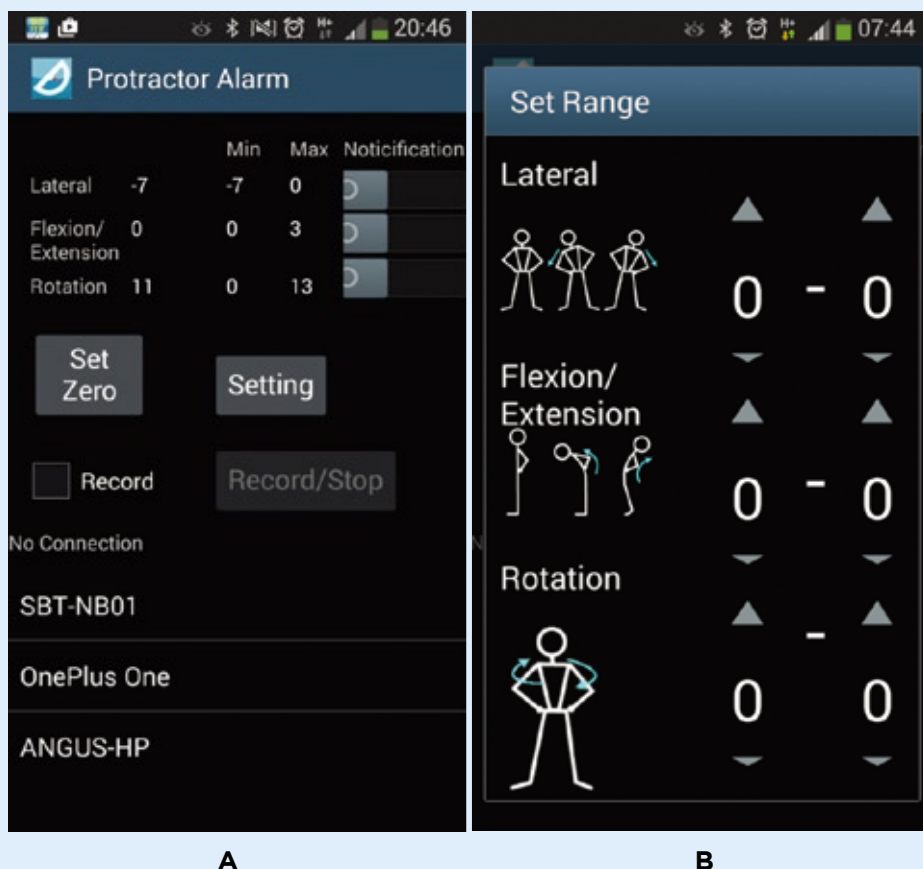


Figure 3.5 Menu of the android based smart phone application

### Result

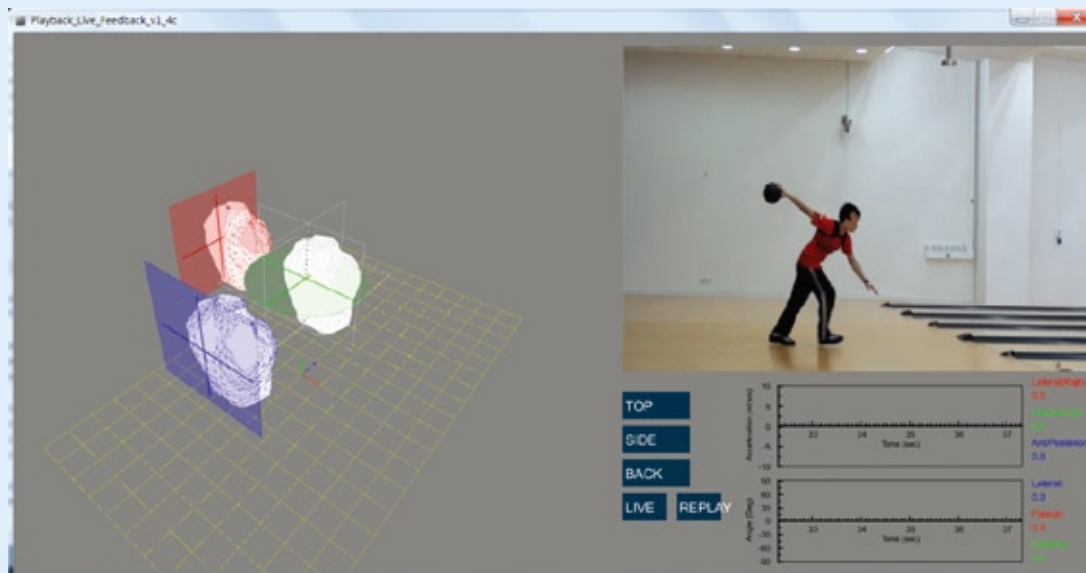
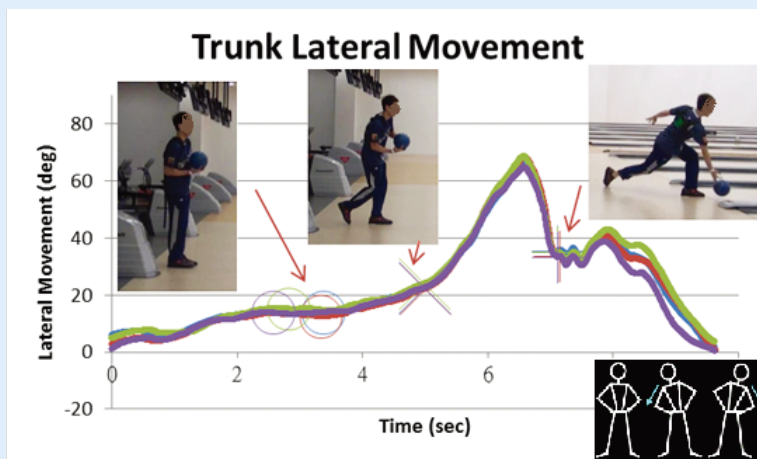


Figure 3.6 Application on Tenpin bowling

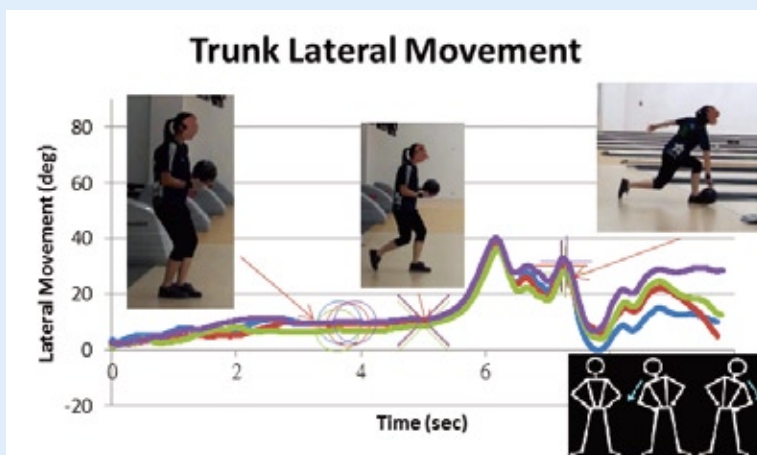


The body orientation detection system, as shown in Figure 3.6, was applied to Hong Kong Tenpin Bowling Team. The study aimed to find out the range of the movement of the body segments and provide instant feedback on skill consistency training. The data was also valuable to our strength and conditioning coaches to plan for sports specific training to our athletes. Four trials were measured and synchronised at right foot takeoff moment. These data, included lateral movement, flexion and rotation, were overlaid and plotted separated by using MS Excel. One of the parameters that we interested was the trunk lateral movement (Figure 3.7). The pattern of movement was found to be individualised. In this regard, consistency was the major concern in this testing.

In conclusion, body orientation feedback system could quantify the body segment rotation in a more convenient and scientific way. Kinematic data in terms of range of movement and angular velocity were recorded. As over range movement may cause sport injury, system can provide acoustic and vibration feedback to warn athletes.



**A**



**B**

Figure 3.7 Trunk lateral bending during preparation phase

## EQUIPMENT INVENTORY

| Equipment   | Brand & Model  | Quantity | Purpose of use  |
|---|--|----------|---|
| Data collection interface   | National Instrument Labview 2014 developer suite professional edition and NI9215 data acquisition card | 1        | Data collection interface                               |
| Data analysis software  | Mathlab 2015b  | 1        | Data manipulation and processing                        |
| Digital oscilloscope  | Tektronix TDS3014C   | 1        | Signal form detection                                   |
| Function generators   | B&K Precision 4084   | 1        | Signal feeder   |
| Data storage and backup system  | Synology 76T   | 1        | Video data storage and backup                           |
| Wearable real time feedback device  | Google Glass   | 1        | Instant data feedback                                   |
| Video feedback and analysis system in HK cycling velodrome  | -  | 1        | Video and data feedback during training and competition |
| Training video feedback systems in tenpin bowling, squash, karatedo, table tennis, billiard sports, disabled sports training venues | -  | 1        | Video feedback during training                          |



# CHAPTER 4

# SPORT NUTRITION MONITORING CENTRE

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## Introduction

Performance nutritionists and dietitians at the Sport Nutrition Monitoring Centre provide a four-pronged approach to improving athletic performance. Through the application of current research, the Centre ensures athletes receive today's best practices in each element of its provision:

- **Individual and team nutrition strategies:** Strategies focus on tailoring nutrition to meet the demands of the sport;
- **Biochemical performance analysis:** This element monitors training adaptations and provides objective data on which the Centre advises;
- **Food provision:** The Centre ensures athletes have every opportunity to fuel optimally for training, recovery and performance; and
- **Education and research:** Providing athletes with the knowledge and tools to achieve athletic success is the fundamental element of the Centre's service.

Through an athlete-centred approach to performance nutrition, the Centre ensures each athlete has the time and energy to train and perform at their best.

## 4.A Sport Biochemistry

As part of the Sport Nutrition Monitoring Centre, Sport Biochemistry Unit monitors athletes' physical conditions and responses to training stress at the molecular level. This information facilitates coaches in designing an effective individualised training programme

### SERVICE PROVISION

The following paragraphs describe the application of the commonly used biochemical parameters and their clinical significance particularly the importance of each biochemical test to athletes. According to the purpose of performing the test, the biochemical tests can be classified into below categories:

- Training and recovery monitoring;
- Exercise testing and functional assessment; and
- Monitoring of health status.

Under different circumstances, some of the parameters can serve more than one function and help the athletes in different aspects. Flexibility in the choice of test is important.

#### 1 Training and recovering monitoring

Athletes must undergo training in order to have their performance improved. A good training programme stresses the body and helps the body to reach an advanced level. The improvement in performance after training is called super compensation. In order to have the body adapt to the training programme and reach the supercompensation status, appropriate rest and recovery from each training session is critical.

If there was too much rest and recovery, and no appropriate training stimuli were imposed during the supercompensation status, the body will not adapt to an advanced level. Under-training will lead to deterioration of performance. However, if there was too much training without adequate rest and recovery, performance will also deteriorate as a result of over-training. The effect of over-training can carry over for several weeks to months before an athlete can recover. This affects performance seriously.

Mild over-training is called overreaching. It requires several days to recover. In order to achieve good training effects, overreaching is widely used by coaches in training. Many athletes are often trained on the edge of overreaching.

In order to prevent over-training and under-training, a regular monitoring of the balance of training and recovery of athletes is important. The biochemical tests provide an objective measure to monitor training and recovery. The best time to collect blood and urine samples is before breakfast and before exercise. This reduces the potential influence of diet and exercise to the biochemical tests. If this timing of sampling is not practical, blood sampling can be performed at the same time of the day. However, at least three hours of rest should be allowed after exercise.



The most commonly used biochemical parameters for training monitoring are creatine kinase, urea, haemoglobin, testosterone, cortisol, and the ratio of testosterone and cortisol.

### *Creatine kinase (CK)*

CK is a protein enzyme involved in energy metabolism. It is mainly found in skeletal and cardiac muscles. When these muscles are damaged, CK will be released into the blood stream and the level of blood CK will increase. CK is mainly used to screen for heart diseases in clinical settings. If it is applied to athletes, it is used to monitor muscular response to training stress. Repetitive muscle contraction during exercise may induce micro-injury to the muscle cells. Permeability of cell membranes may also increase temporarily. Small particles, like CK, inside the cells will leak into the blood stream. The peak level of CK appears at 8 - 16 hours post-exercise. Therefore, the preferable time to measure CK level is the day after exercise.

Various factors affect serum CK level after exercise: muscle mass involved in the exercise, type of muscle contraction, and personal experience in training etc. The greater the muscle mass involved in the exercise, the greater the magnitude of the increase in serum CK level. In eccentric contraction, muscle cells are stretched while bearing high contraction tension. The cell membranes are damaged and CK level increases to a greater extent. When athletes perform unaccustomed exercise, CK level also increases more because muscles involved are those not normally recruited during the accustomed exercise. Significant increase in CK is also expected if exercise intensity is high and after weight training.

The normal CK level of an average person is about 100 U/L if no exercise is performed. Generally, males have higher CK levels than females. Athletes have significantly higher CK levels than the average persons. Sport specificity and individual difference have significant influence on response of CK to exercise. When interpreting CK level for athlete, it is preferable to compare to the CK measurements obtained at different training phases of the same athlete. As such, the increase in CK level can indirectly help to assess the training stress and the adaptability of athletes to previous training. When the increase in the magnitude of CK level is lower than expected, this reflects the training stress is low. When the increase in the magnitude of CK level is persistently higher than expected, this reflects training stress is too high that muscles cannot adapt. The training plan, therefore, may need to be modified. To facilitate muscle recovery, athletes can perform stretching after exercise when the CK level is high.

### *Urea*

Urea is a by-product of protein metabolism. It is generated in the liver and excreted from the body via urine. Normally, production and excretion of urea are kept in balance and therefore maintains a stable blood urea level. In clinical settings, blood urea is used to check kidneys function. When the kidneys function is impaired, the rate of urea excretion decreases and the concentration of blood urea increases. Tissue damages and dehydration also lead to the increase in blood urea. Apart from being the main component of tissues, protein is also used for energy generation. For instance, at times of high training volume in accompany with reduction of glycogen store, protein stored in

the body is used to generate energy. When protein is metabolised, energy and urea are produced and therefore increases blood urea level. Urea increases when training load is too high for the body to adapt. Therefore, urea can be used to reflect stress to the energy system of athletes. Other reasons for an increase in blood urea include: high protein and low carbohydrate intake and cold weather.

Blood urea test should be conducted on the day after exercise. If blood urea is high in the next morning after exercise and then recovered to normal level, training load is high enough and the body adapt well to the training programme. However, if blood urea continues to increase beyond the next morning, the body does not adapt to the training programme. Modification of the programme is indicated. Reduction of training load and increase in carbohydrate intake may be necessary for the athlete.

### *Haemoglobin*

Refer to **3 Monitoring of health status**.

### *Testosterone*

Testosterone is the most active androgens in the body. Testosterone level is affected by luteinising hormone (LH) and follicle stimulating hormone (FSH). The largest amount of testosterone is produced by the testes in men and is also synthesised by adrenal glands in both sexes. Small amount of testosterone is produced by ovaries in women which is eventually transformed to estrogen. The main functions of testosterone include facilitating the development of the male secondary sex characteristics and modulating the function of sex gland. Testosterone can also enhance the synthesis of phosphocreatine, growth of muscle and bone, stimulation of erythropoietin secretion, and increase in muscle glycogen store, etc.

Clinically, testosterone plays a key role in monitoring puberty disorder, sexual dysfunction, infertility etc. For athletes, regular measurement of testosterone can be used for monitoring training and recovery status.

The reference range of testosterone for male athletes is 2.7 - 10 ng/mL and that for female athletes is 0.1 - 1.0 ng/mL. Significant individual difference in testosterone level suggests that data obtained from an athlete should be compared to his/her personal norm as deduced from the previous data obtained for the same athlete. When the body is functioning well, testosterone level is stable. When the body is not functioning well or over-trained, testosterone level decreases. The increase in testosterone represents strong anabolism in the body and indicating that the athlete responses well to intensive training. Regular testosterone measurement during training monitors body function of an athlete. If testosterone level decreases and is persistently below 25% or the pre-training level, modification of training programme should be considered.

### *Cortisol*

Cortisol is one of the glucocorticoids and is synthesised in the adrenal cortex. When the body is under stress or being stimulated, the release of cortisol increases. The major functions of cortisol are to promote nutrient catabolism, modulate immune system, attenuate response of the nervous system to stimulation, and influence performance of

muscle. The level of serum cortisol undergoes diurnal variation. It rises in the morning reaching its maximum level at about 8 am and decreases considerably in the evening. Cortisol level is readily affected by many factors. It is advisable to collect samples for cortisol at the same time of the day. Morning level of cortisol ranges 60 - 260 ng/mL; afternoon level ranges 20 - 90 ng/mL; midnight level ranges 20 - 50 ng/mL. Data should be compared against individual norm because of the significant individual difference in cortisol level. Regular monitoring of cortisol level during training is recommended. In general, cortisol level reflects the rate of catabolism in the body. If cortisol level is high, it encourages catabolism in the body. It is unfavourable to recovery and may induce overtraining.

### *Testosterone/Cortisol ratio (T/C Ratio)*

T/C ratio reflects the balance between anabolism and catabolism in the body. If T/C ratio decreases drastically, it represents catabolism is greater than anabolism. This is unfavorable to stress recovery. Enforcement of recovery measures and consideration of training programme modification are advisable, or else over-training may result. When both testosterone and cortisol decrease and accompanied with an increase in T/C ratio, this does not mean that the body is in good condition. If the level of testosterone is very low, the body's exercise capacity may be impaired.

## **2 Exercise testing and functional assessment**

The parallel use of biochemical test and exercise test will allow additional information about the athlete's energy system and functional capacity to be reviewed. In considering the need from different sports, coaches can use the information to design the most effective training programmes for the athlete.

### *Blood lactate*

The concentration of blood lactate represents the balance between the production and the removal rates of lactate. It relates to the energy system being used during exercise. Regular measurement of blood lactate during training provides information on the exercise intensity and the developmental status of the energy systems of individual athlete. Blood lactate measurement can be applied to various exercise tests. Most commonly, it is used at the last phase of a maximum oxygen uptake test and during progressive graded exercise test. The former helps to determine if the athlete has reached the maximum oxygen uptake level. The latter allows preparation of the blood lactate curve. The lactate curve helps prescription of exercise intensity and assessment of training status for individual athlete.

At rest, blood lactate should be around 1 - 2 mM. The post exercise lactate level is influenced by various factors, including the training status of the athlete's energy systems, exercise duration, exercise intensity, and muscle glycogen store, etc. Broadly speaking, when ATP-PC system is the major source of energy, blood lactate should be below 4mM. When lactate system becomes the major source of energy, blood lactate can reach 15mM. When the exercise sustains and aerobic system becomes the major source of energy, blood lactate should be around 4 mM. Depending on the training arrangement, exercise heart rate, and exercise blood lactate concentration, different training method can attain different training objectives (Table 4.1).

| Type                   | Blood lactate concentration (mM) | Exercise heart rate (%HR maximum) | Continuous or intermittent exercise         | Major objective  |
|------------------------|----------------------------------|-----------------------------------|---|--|
| 1. Recovery            | < 2                              | < 70%                             | Continuous                                  | <ul style="list-style-type: none"> <li>• Maintain general fitness</li> <li>• Help recovery from intense exercise</li> </ul>                                |
| 2. Aerobic capacity    | 2 - 4                            | 70 - 85%                          | Continuous                                  | <ul style="list-style-type: none"> <li>• Improve metabolism and removal of blood lactate</li> </ul>  |
| 3. Anaerobic capacity  | 4 - 8                            | 85 - 95%                          | Continuous or intermittent                  | <ul style="list-style-type: none"> <li>• Improve metabolism and removal of blood lactate</li> <li>• Enhance maximum oxygen uptake</li> </ul>               |
| 4. Anaerobic endurance | > 8                              | > 95%                             | Intermittent                                | <ul style="list-style-type: none"> <li>• Allow the body to get used to high blood lactate</li> <li>• Able to sustain exercise at high intensity</li> </ul> |
| 5. ATP-PC              |                                  | > 90%                             | Intermittent - Short duration, long resting | <ul style="list-style-type: none"> <li>• Develop ATP-PC system</li> </ul>  |
| 6. Resistance          |                                  |                                   | Intermittent                                | <ul style="list-style-type: none"> <li>• Develop muscle strength and endurance</li> <li>• Injury prevention</li> </ul>                                     |

Table 4.1 Classification of training methods

### Blood gases

Measurement of blood gases refers to measurement of the following parameters in the blood: oxygen partial pressure ( $pO_2$ ), carbon dioxide partial pressure ( $pCO_2$ ), and pH etc. The measure of blood gases during exercise tests, such as maximum oxygen uptake test and progressive graded exercise, helps to assess the aerobic capacity and gas exchange ability of an athlete.

## 3 Monitoring of health status

In the annual medical check-up, doctor will perform physical examination and the Sport Biochemistry Unit will conduct various blood and urine tests on our athletes. The major purpose is to help early detection of sub-clinical problems. This will ensure that training quality can be maintained by early identification and treatment of any underlying problem. The frequency of measurement for each parameter will depend on the need of different athletes.

### Complete blood count (CBC)

The test measures white blood cell, red blood cell, and platelet in the blood. Our laboratory uses Sysmex XT-2000i for measuring CBC.

### *White blood cell count (WBC)*

White blood cell is one of the components of blood. It is produced and matures in bone marrow and lymph. Its function is to protect our body against foreign bodies. White blood cell count refers to the sum of various kinds of white blood cell in the body. Sysmex XT-2000i can distinguish white blood cells into five groups: neutrophils, lymphocytes, monocytes, eosinophils, and basophils. Change in the number of any kind of these white blood cells will affect the white blood cell count. The normal white blood cell count should be 4.0 - 11.0 K/ $\mu$ L.

There are numerous reasons for an increase in white blood cell count. Examples are: exercise, bacterial infection, inflammation, trauma, pressure, leukemia, etc. Reasons for a decrease in white blood cell count include: immunological diseases, chemotherapy, radiotherapy, etc.

Neutrophils' primary function is to engulf bacteria and cell debris. The mucus membrane in the nose and throat that can prevent bacterial infection is largely deal to the presence of neutrophils. Various stresses, chemotherapy, and radiotherapy reduce the number of neutrophils and increase risks of bacterial infection. Bacterial infection and inflammation increase neutrophils. However, severe infection and certain medicine will reduce neutrophils. The norm for neutrophil is 1.8 - 7.5 K/ $\mu$ L (40 - 75% of WBC).

Lymphocytes' primary function is to destroy cells infected by virus. Lymphocytes produce antibodies to destroy virus. Lymphocytes increase in viral and bacterial infections, radiotherapy, and leukemia. Diseases that affect the immune system (e.g. lupus erythmatosus and later stage of AIDS) will cause a decrease in lymphocytes. The norm for lymphocyte is 1.5 - 4.9 K/ $\mu$ L (20 - 40% of WBC).

Monocytes serve as phagocytes to engulf bacteria, other foreign bodies and cell debris. The norm for monocyte is 0.2 - 0.8 K/ $\mu$ L (2 - 10 % of WBC).

Eosinophils use chemicals to fight against foreign cells. It increases in allergic conditions, skin inflammation, parasitic worm infections. Certain infections will however decrease eosinophils. The norm for eosinophil is 0.04 - 0.44 K/ $\mu$ L (1 - 5 % of WBC).

Basophils increase in infections. They accumulate at infected and inflammatory sites. Chemicals are released and lead to inflammatory reactions. Chronic inflammation food allergy, radiotherapy, leukemia can lead to an increase in basophils. Acute inflammation, stress and hyperthyroidism will lead to a decrease in basophils. The norm for basophil is 0.01 - 0.10 K/ $\mu$ L (<1% of WBC).

### *Red blood cell count (RBC)*

The primary function of red blood cell is for transport of oxygen and carbon dioxide. Its average life span is 120 days. RBC is influenced by the change in blood plasma volume. Dehydrated athletes will have their RBC increased. An increase in blood plasma volume will reduce the RBC. The norms for RBC are: male: 4.5 - 6.0 M/ $\mu$ L; female: 3.7 -5.2 M/ $\mu$ L.

## Haemoglobin (Hb)

Haemoglobin is an iron containing protein in red blood cell. Its primary function is to carry oxygen and carbon dioxide. It also serves as a buffer against acids and helps balancing pH in the body. A low haemoglobin level represents anemia and will decrease endurance of athletes. A high haemoglobin level can be caused by dehydration or exposure to high altitude. Different kinds of anemia can be found in Table 4.2.

|                               |   |
|-------------------------------|---|
| <b>Sports anemia</b>          | Athletes may have difficulty in adapting to an increase in training volume and training intensity at the early stage of a new training programme. The rate of haemoglobin production is lower than that of haemoglobin breakdown. This will lead to a temporary decrease in haemoglobin concentration. Modification of training programme and active recovery will remove this kind of anemia. Haemoglobin concentration, on one hand, influences endurance of athletes and, on the other hands, reflects how the body adapted to the training programme. Regular measurement of haemoglobin level can monitor both training stress and recovery level of athletes. |
| <b>Iron deficiency anemia</b> | Metabolism of iron is faster in athletes when compared to that for average people. If iron intake via food consumption does not match with the turnover rate, athletes will suffer from iron deficiency anemia. Female athletes and vegetarian athletes are more risky towards iron deficiency. The former tends to lost iron via menstruation. The later has lower iron intake, as it is more difficult to absorb iron from vegetables when compared to that from meats.   |
| <b>Hereditary anemia</b>      | Thalassemia is common at the southern part of China. There is about 8% of Hong Kong people suffers from this problem. Among these patients, most of them do not have obvious symptoms. People suffers from minor thalassemia can become elite athletes after proper training. However, due to a lower haemoglobin level, the development of endurance capacity of these people will be limited. Furthermore, athletes suffering from thalassemia may have their haemoglobin further reduced after intense training. Regular monitoring becomes particularly important. The norm for haemoglobin is: male: 13 - 18 g/dL; female:12 - 16 g/dL.                        |

Table 4.2 Different kinds of anemia (low haemoglobin level) commonly found among athletes

## Haematocrit (Hct)

Haematocrit refers to the percentage of red blood cells in the plasma. It basically changes with RBC and haemoglobin concentration. Any increase or decrease in plasma volume will change haematocrit. The norm for haematocrit is: male: 40 - 50% ; female: 35 - 46%.

## Mean corpuscular volume (MCV)

Mean corpuscular volume measures the mean or average size of individual red blood cells. It can help distinguish various kinds of anemia. As the newly formed RBCs are larger in size, exercise stress causes haemolysis, increases destruction of RBC, and leads to increase in MCV.

Other causes of increase in MCV include: liver disease, alcoholism, folic deficiency anemia, B12 deficiency anemia, and other macrocytic anemia. The major causes of decrease in MCV include: iron deficiency anemia, thalassemia and other microcytic anemia. The norm for MCV is 80.0 - 98.0 fL.



### Mean corpuscular haemoglobin (MCH)

Mean corpuscular hemoglobin measures the amount of hemoglobin present in one RBC. Both iron deficiency anemia and thalassemia are accompanied with a lower MCH. The norm for MCH is 27.0 - 35.6 pg.

### Mean corpuscular haemoglobin concentration (MCHC)

It can be calculated by the formula  $MCHC \text{ (g/l)} = \text{Haemoglobin content per 1 litre of blood} / \text{Haematocrit} * 100\%$ . A low MCHC is usually caused by iron deficiency anemia and thalassemia. A high MCHC is usually caused by severe dehydration. The norm for MCHC is: 32.6 - 36.6 g/dL.

### Red blood cell distribution width (RDW)

Red blood cell distribution width represents the range that covers the smallest and largest RBC in your body. It reflects the degree of difference in size of the RBCs. When anemia is caused by iron deficiency and folic/vitamin B12 deficiency, both large and small RBCs are present. Although the MCV tend to be normal, the RDW will increase. Iron deficiency anemia and thalassemia will also cause a high RDW. The norm for RDW is 11.0 - 15.0%.

### Platelet (Plt)

Platelets become critical when injury occurs. When blood vessels break, platelets form plugs that prevent further blood loss while healing takes place. Leukemia, removal of spleen, and polycythaemia lead to an increase in platelet counts. A reduce in platelet count may indicate hemolytic anemia, chemotherapy, excessive blood loss, etc. The norm for platelet is 150 - 400 K/ $\mu$ L.

### Total cholesterol

Cholesterol is a kind of lipid. Part of it originates from food consumption and yet some is produced by the body itself. Cholesterol is the major building block of cellular membrane and also forms part of steroids, bilirubin, and vitamin D. As cholesterol level is influenced by quite a number of factors (e.g. diet, living style, gender, and age), marginal cholesterol levels indicates retest at intervals to closely observe its changes.

High cholesterol level is associated with coronary disease. Measuring cholesterol and other lipids can be used to estimate the risk of coronary disease (Table 4.3).

| Total cholesterol |             |                                   |
|-------------------|-------------|-----------------------------------|
| mg/dL             | mmol/L      | Risk of coronary disease          |
| <200              | <5.18       | Low risk (desirable)              |
| 200 - 239         | 5.18 - 6.18 | High risk (borderline high)       |
| >240              | >6.21       | Twice the risk as desirable level |

Table 4.3 Using blood lipid concentrations to estimate risk of coronary disease

There are a number of reasons leading to a high cholesterol level. They include: excessive consumption of food with high cholesterol level, hereditary high cholesterol level, fatty liver, nephritis, hypothyroidism, stress, diabetes, etc. A low cholesterol level may be caused by poor absorption, indigestion, hyperthyroidism, liver disease, etc. The norm for total cholesterol is <200 mg/dL or <5.18 mmol/L.

### *High density lipoprotein cholesterol (HDL cholesterol)*

HDL cholesterol is one of the cholesterol in the blood. It is usually referred as the good cholesterol. Low density lipoprotein cholesterol (LDL cholesterol) is another cholesterol that is being considered as the bad cholesterol.

HDL cholesterol in the blood will be transported to the liver for break down and therefore lower the lipid level in the blood. At the same time it will suppress uptake and storage of the harmful LDL cholesterol by the cells. This helps to prevent atherosclerosis. Together with other lipid measurements, the measure of HDL cholesterol can be used to estimate the risk of coronary disease (Table 4.4). In contrary, LDL cholesterol transport lipid to other parts of the body. This cholesterol after oxidation will attach to the inner wall of the blood vessels and develop into atherosclerosis. The norm for HDL cholesterol is 40 - 59 mg/dL or 1.04 - 1.53 mmol/L.

| HDL cholesterol |             |                                 |
|-----------------|-------------|---------------------------------|
| mg/dL           | mmol/L      | Risk of coronary disease        |
| >60             | >1.55       | Low risk                        |
| 40 - 59         | 1.04 - 1.53 | Optimal (the higher the better) |
| <40             | <1.03       | High risk (male)                |
| <50             | <1.29       | High risk (female)              |

*Table 4.4 Using blood lipid concentrations to estimate risk of coronary disease*

### *Triglyceride*

Triglyceride is another lipid found in the blood. Part of it is absorbed via food consumption and part of it is synthesised by the body. Its primary function is to supply energy for cells. As the triglyceride level in the blood is highly influenced by timing of meals, blood sampling for triglyceride measurement should be collected after 8 - 14 hours of fasting. Together with measurement of other lipids, the fasted triglyceride level helps to estimate the risk for coronary disease (Table 4.5).

| Triglycerides |             |                          |
|---------------|-------------|--------------------------|
| mg/dL         | mmol/L      | Risk of coronary disease |
| < 150         | < 1.69      | Low risk                 |
| 150 - 199     | 1.69 - 2.25 | Borderline high risk     |
| 200 - 499     | 2.26 - 5.63 | High risk                |
| >500          | >5.65       | Very high risk           |

*Table 4.5 Using blood lipid concentrations to estimate risk of coronary disease*

### *Iron status related parameters*

The main functions of iron in the blood are transportation of oxygen and metabolism. Iron found in haemoglobin makes up to 70% of total iron found in the body. Almost all heme-iron are found in the RBC and the pre-RBC in the bone marrow. Rest of the iron can be found in the liver and spleen.

Iron metabolism in athlete is different from that in the average people. Iron absorption is poorer and yet iron loss is faster in athletes. Iron deficiency is therefore more common among athletes. Athletes under training may have difficulty in adapting to the training programme and leads to hemolysis, iron deficiency, and further developed into anemia. This is especially true for endurance training. Power training also affects iron metabolism, particularly for exercise that involves large muscles. Hemolysis and decrease in the iron store is expected.

|   |   |
|---|---|
| <b>Serum iron</b>   | Serum iron is mainly influenced by food iron content, intestine absorption and iron loss. Consistent low serum iron suggests iron deficiency. Transient decrease in serum iron can be acute response to bacterial infection. Female at the early stage of menstruation also accompanies with a low serum iron. The norm of serum iron for male is 65 - 170 µg/dL. The norm for female is 50 - 170 µg/dL. When interpreting serum iron, it is important to remember that it is readily influenced by various physiological factors and it will be important to conduct tests on other iron related parameters at the same time.  |
| <b>Ferritin</b>   | Ferritin molecule is made up of iron molecule and transferrin. It is present in most cells and its major role is iron storage. In the liver and bone marrow, ferritin supplies iron for the production of haemoglobin. The major purpose of measuring ferritin is to monitor iron status. It is particularly useful for early phase of iron deficiency anemia. A low ferritin level suggests reduction in iron store that may lead to anemia. Excess iron store will increase ferritin level, however a high ferritin may also suggest infection, inflammation, damage to the liver, spleen or bone marrow. The reference range and corresponding recommendation for ferritin measurement can be found in Table 4.7.  |
| <b>Transferrin and Total iron binding capacity (TIBC)</b> | Transferrin combines to iron molecules and transport iron from sites of absorption to sites of utilisation. Serum transferrin concentration is reversibly proportional to the iron status. At times of iron deficiency, transferrin increases. On contrary, transferrin decreases. Its norm is 230 - 450 mg/dL. Total iron binding capacity refers to the maximum capacity of binding iron by transferrin found in the blood. It is an indicator of transferrin content in the blood. Total iron binding capacity (µg/dL) = transferrin (mg/dL) * 1.27. Individuals suffering from iron deficiency anemia will have their TIBC and transferrin increased. An increase in TIBC may also indicate acute hepatitis and polycythemia. Chronic infection, renopathy and certain cancer will reduce TIBC. |
| <b>Transferrin saturation</b>                             | Transferrin saturation refers to the percentage of serum iron in compare to the TIBC. At times of iron deficiency, transferrin saturation decreases. Excessive iron will accompany with high transferrin saturation. The norm of transferrin saturation is 15 - 50%.  |
| <b>Transferrin receptor</b>                               | The function of transferrin receptor is to carry iron and transferrin into cells. It is found on the surface of all cells, especially for those require a high iron supply (e.g. RBC that produce haemoglobin). The measurement of transferrin receptor provides useful information before development of anemia. When activity of erythropoietin increases, and at times of iron deficiency, transferrin receptor increases. Its norm is 0.8 - 2.3 mg/dL.  |

*Table 4.6 Commonly used parameters for monitoring iron status*

| Ferritin (ng/dl) |                      |                | Recommendation   |
|------------------|----------------------|----------------|--|
| < 25             |                      | Too low        | Consult doctor. In the absence of major blood loss, take iron supplement and continue follow-up.             |
| Male<br>Female   | 25 - 45<br>25 - 35   | Border<br>line | Consult nutritionist. Take iron supplement under supervision. Continue follow-up until condition stabilised. |
| Male<br>Female   | 45 - 100<br>35 - 150 | Normal         | Refer to other iron related parameters. Provide recommendation based on individual athlete's situation.      |
| Male<br>Female   | > 300<br>> 150       | Too High       | Consult doctor and undergo related tests (e.g. liver function tests).  |

Table 4.7 Reference range for ferritin

## Osmolality

Osmolality refers to the concentration of dissolved particles in a solution. Serum and urine osmolality can be used to monitor water balance of athletes.

### Serum osmolality

Serum osmolality can be used to monitor water balance of athletes and to evaluate other abnormal conditions. For instance, high serum osmolality can be caused by diabetes or alcohol consumption. Low serum osmolality can be caused by excessive water intake and abnormal secretion of anti-diuretic hormone.

### Urine osmolality

Urine osmolality and urine sg can both indicate concentration of urine. However many molecules present in the urine affect urine sg. Urine osmolality will be a better indicator of urine concentration and water balance. The reasons for an increase or decrease in urine osmolality are similar to that for serum osmolality. Dehydration will lead to an increase in urine osmolality and excess hydration will lead to a decrease (Table 4.8).

| Serum osmolality                   | Urine osmolality                   | Interpretation                                       |
|------------------------------------|------------------------------------|--|
| Reference range:<br>282 - 295 mOsm | Reference range:<br>500 - 800 mOsm |  |
| Normal or increased                | Increased                          | Decrease in water store -<br>dehydration             |
| Decrease                           | Decrease                           | Excessive water store -<br>Over consumption of water |
| Normal                             | Decrease                           | Increased water consumption<br>or use of diuretics   |

Table 4.8 Use of serum osmolality and urine osmolality to monitor water balance

## Liver function tests

Liver function tests refer to a few commonly used parameters used for monitoring liver functions (Table 4.9).

|  |  |
|--|--|
| <b><math>\gamma</math>-Glutamyltransferase (GGT)</b>                             | Large amount of GGT can be found in the cell membrane of liver, spleen and kidney. It is an important indicator for liver damage. Various liver diseases will lead to profound increase in serum GGT activity. Chronic alcoholism also induces an increase in GGT. Transient increase in GGT can be caused by viral infection that affects the liver, large consumption of alcohol, intake of barbiturate or pain-killers. The norm of GGT for male and female is 12 - 64 U/L and 9 - 36 U/L respectively.   |
| <b>Alanine transaminase/ Glutamine pyruvate transaminase (ALT/ GPT)</b>          | ALT is almost exclusively present in liver cells. Liver damage or necrosis will release ALT from cells into the blood stream and leads to increase in serum ALT. Since the circulation of ALT in the blood takes a longer time when compared to that of glutamic-oxaloacetic transaminase (AST), and ALT will be significantly increased by viral hepatitis. The use of ALT for monitoring damage to the liver is therefore more specific than the use of AST. The norm for male and female is below 40 and below 31 U/L respectively.   |
| <b>Aspartate aminotransferase / Glutamic-oxaloacetic transaminase (AST/ GOT)</b> | AST is widely found in various tissues of the body. The descending order of abundance is: heart, liver, skeletal muscles, and kidney. Serum AST activity is low under normal conditions. When tissues are damaged, the enzyme will be released into the blood stream and thus AST activity increases. The norm for male and female are below 37 and 31 U/L respectively. Together with other tests, AST can be used to assist identifying which tissue is being damaged.   |
| <b>Alkaline phosphatase (ALP)</b>  | ALP is one of the enzymes that catalyse hydrolysis of phosphorus. It can be found in the liver, kidney, bone and intestine. For adult, most ALP is originated from the liver. Damage to the tissue will release ALP into the blood stream and increase the serum ALP activity. Viral infection to the liver and liver disease that affects the bile duct will lead to a significant increase in ALP. The norm for ALP is 39 - 117 U/L. Children and adolescents under growth period have higher ALP. Injury to the bone will also induce an increase in ALP. Together with other tests, it will be able to identify if the liver is damaged or not.  |
| <b>Hepatitis and related indicators</b>  | Hepatitis A is transmitted via the digestive tract. It is mainly transmitted through dirty hands, contaminated food, and partially cooked shellfish. Individuals infected may not have typical symptoms. Liver functions can be normal too. Some infected people may have fever, joint aches, general weakness, poor appetite, nausea (or even vomiting), tympanites, diarrhea, and even experience jaundice a few days later. This is acute hepatitis. Some people will only have mild symptoms, no jaundice is experienced, and liver functions increase (AST, ALT). This is sub-clinical hepatitis. Athletes frequently travel to overseas for training and competition. There may be chances to travel to countries with poor hygiene. In order to prevent catching hepatitis that affects training and competition, they should be tested for IgG antibody to hepatitis A virus (IgG anti - HAV) on regular basis. Details about the test and its interpretation can be referred to Table 4.10. |

Table 4.9 Commonly used parameters for monitoring liver functions

| IgG anti-HAV (Signal/Cut off) | Meaning      | Recommendation                       |
|-------------------------------|--------------|--------------------------------------|
| < 1.0                         | Non-reactive | Receive vaccines against hepatitis A |
| $\geq$ 1.0                    | Reactive     | Protected against hepatitis A        |

Table 4.10 Test for IgG antibody to hepatitis A virus (IgG anti-HAV)



Hepatitis B is caused by virus and transmitted via blood. Transmission can be caused by contaminated needles, infected person's saliva, mucus, close personal touch and unsafe sexual contact. Usually symptoms appear three month after infected. Symptoms include poor appetite, vomiting, diarrhea, and tympanites. Some infected people will also suffer from fever and jaundice. About half of the infected people will not have obvious symptoms. Most people infected with hepatitis B recover after treatment. A small number of the infected people will develop into chronic condition. Some of them will end up into cirrhosis and even liver cancer. Another small number of the infected cases will develop into severe hepatitis. Some others will become carriers without any symptoms. Athletes travel and live together as a group during overseas trips. And there are a lot of chances for athletes to have close contact with other athletes during competitions. In order to prevent being infected with hepatitis B, it is important to undergo related tests and receive vaccination if suggested by the test results.

In order to confirm if an individual is a carrier of hepatitis B, hepatitis B surface antigen (HbsAg/HBS) test should be conducted. A negative result suggests that the individual has not been infected. The test for antibody to hepatitis B surface antigen (anti-HBs/HBST) will help to confirm if an individual will need to receive vaccination against hepatitis B. Details about the recommendation can be found in Table 4.11.

| HBST (mIU/ml) | Meaning    | Recommendation  |
|---------------|------------|---|
| < 5           | Negative   | Receive vaccine against hepatitis B.  |
| 5 - 10        | Borderline | Receive test for antibody to hepatitis B core antigen (anti-HBc). Positive result suggests that the individual has enough protection against hepatitis B, otherwise should receive vaccine against hepatitis B. |
| > 10          | Positive   | Protected against hepatitis B, no vaccine is needed.  |

*Table 4.11 Interpretation of HBST test*

## Urinalysis

This laboratory uses 10-parameter urine test strips for urinalysis. The major purposes of conducting the test are for general medical check-up, training monitoring and monitoring of water balance. Introduction for the various parameters are listed in Table 4.12.

|                              |  |
|------------------------------|--|
| <b>Specific gravity (sg)</b> | <p>Specific gravity of urine refers to the ratio between the densities of urine to that of water. The higher concentration of urine, the higher the sg of it will be. Urine sg reflects athletes' water balance. A high urine sg may suggest dehydration. Excessive water intake will lead to a significant drop in urine sg. The change in urine sg after exercise depends very much on the sweating rate and fluid consumption rate. It is therefore affected by temperature, humidity, exercise intensity, duration of exercise.</p> <p>Under normal conditions, urine sg should range between 1.005 and 1.030. A high urine sg may suggest acute inflammation of kidney, fever, poor cardiac function, diabetes, etc. A low urine sg is usually caused by poor kidney function, glomerulonephritis, and excessive water intake.</p>  |
| <b>pH</b>                    | <p>Urine pH is affected by food, medicine and disease. A higher pH is expected if food is mainly comprised of fruit and vegetables. A lower pH is expected if a lot of meat and protein has been consumed. For clinical cases, increase in acidity (decrease in pH) of urine is associated with fever, diabetes, and consumption of ammonium chloride. Increase in alkaline level (increase in pH) of urine is associated with vomiting, blood transfusion, inflammation of bladder, and consumption of sodium bicarbonate.</p>  |
| <b>Leukocytes (Leu)</b>      | <p>Normal urine should not contain leucocytes. Presence of leucocytes may suggest urinary tract infection, inflammation, nephritis, urinary stones, etc.</p>   |
| <b>Nitrite (Nit)</b>         | <p>Normal urine sample should not contain nitrite. When E. Coli or other bacteria is present in the urine, nitrate in the urine will be converted into nitrite. Presence of nitrite is therefore suggested urinary tract infection, and nephropylitis, etc.</p>  |
| <b>Protein (Pro)</b>         | <p>Urine sample from adult should contain very small amount of protein that cannot be detected by the average method (including urine test strips). The increase in protein in urine is called proteinuria. Non-pathological reasons for proteinuria include exercise, cold, heat, pregnancy, and the use of medicine for blood vessel restriction. This kind of proteinuria is only transient. Pathological causes of proteinuria include poor cardiac function, renal diseases, etc.</p> <p>For athletes, exercise induced proteinuria is common. Testing for the presence of protein in urine can be used for training monitoring. Large individual difference can be found in exercise- induced proteinuria. Some athletes will readily develop proteinuria with high protein level after exercise. Others will not develop proteinuria readily and even develop will only have small amount of protein found. Reasons for this individual difference have not been identified and it is not appropriate to compare the degree of proteinuria between athletes.</p> <p>Training induces increase of protein in urine. It may last until next morning or even longer. This suggests that the body is not adapting well to the training programme. Urine protein increases after training and returns back to normal level within four hours or in the next morning suggests that although training intensity and volume are high, the athlete recovery well from the training stress.</p> |
| <b>Glucose (Glu)</b>         | <p>Normal urine should only contain a small amount of glucose. Average test (including urine test strip) should not be able to detect it. Only when the glucose level increase to 50 mg/dl, the test will return with a positive result. Physiological causes for an increase in urine glucose is common after high carbohydrate intake. Pathological increase can be caused by diabetes, hyperthyroidism, antuitarium, hyperadrenocorticism, etc. The norm for urine glucose is below 50 mg/dL.</p>   |

|                           |  |
|---------------------------|--|
| <b>Ketones (Ket)</b>      | <p>Ketones refer to acetoacetate, beta-hydroxybutyrate, and acetone. They are the by-products of oxidation of fatty acids that occurs in the liver. After being produced in the liver, they are transported via the blood stream to cardiac muscles, skeletal muscles, kidney, and brain, etc. for further oxidation to release energy.</p> <p>Under normal conditions, ketones will be metabolised and should not be present in large amount in the blood and urine. Urine ketones should not be detectable by the average methods (including urine test strip). Physiological reasons for a high ketones level include: starvation (e.g., fasting), weight control (decrease in carbohydrate and increase in protein intake), exercise (undergoing endurance exercise), and excessive alcohol intake, etc.</p>   |
| <b>Urobilinogen (Ubg)</b> | <p>Urobilinogen is a by-product of haemoglobin breakdown. Under normal conditions, urine urobilinogen should not be detectable by the average methods (including urine test strip). The common reasons for an increase in urobilinogen are: hemolytic anemia, severe constipation, hepatitis, and bile duct obstruction.</p> <p>For athletes, high training stress will induce hemolysis. Both production and excretion of urobilinogen increase. When the reduction in haemoglobin is accompanied with poor subjective feeling, it may need to consider modifying the training programme to promote recovery.</p>   |
| <b>Bilirubin (Bil)</b>    | <p>Bilirubin is another by-product of haemoglobin breakdown. Its mechanism of change is similar to that of urobilinogen. Under normal conditions, urine bilirubin should not be detectable by the average methods (including urine test strip). Increase in urine bilirubin is usually associated with various diseases of the liver and bile duct. Exercise does not affect urine bilirubin significance.</p>   |
| <b>Hematuria</b>          | <p>Hematuria can be further divided into gross hematuria and microhematuria. The former refers to the brown and tea color of the urine. The latter will have urine with normal color but red blood cells can be detected under microscope.</p> <p>Exercise induced hematuria may be caused by the exercise induced changes in the chemistry of blood or changes in the blood circulatory mechanism. These caused transient blood restriction to the kidney and hypoxia and leads to increase permeability of the kidneys. The RBC that originally cannot pass through the glomerulus will now readily goes through and being found in the urine.</p> <p>During period of intense and high volume training, the body cannot adapt to the training and result in hematuria. It is particularly common during altitude training and after weight bearing exercise.</p> <p>For female who suffers from hematuria, it is important to consider the possibility of menstruation first.</p> |

*Table 4.12 Various parameters for urinalysis*

## EQUIPMENT INVENTORY

The Sport Biochemistry Laboratory is equipped with different biochemistry instruments to measure various biochemical parameters. Some of these instruments are portable and readily carried and used in on-field and overseas training supports.

| Equipment  | Brand & Model  | Quantity | Purpose of use (Major parameters being tested)  |
|--|--|----------|---|
| Haematology system                                     | XT-2000i, Japan, Sysmex  | 1        | Complete blood count, 5 parts differential leukocyte count, reticulocyte count.   |
| Integrated biochemistry and immunoassay testing system | Architect ci4100, USA, Abbott  | 1        | Creatine kinase, urea, cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol triglyceride, $\gamma$ -glutamyl transferase, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, testosterone, cortisol, iron, ferritin, transferrin, hepatitis A virus antibody, hepatitis B surface antigen, hepatitis B surface antibody. |
| Bench-top biochemical analyser                         | Reflotron Plus, Germany, Boehringer Mannheim                                     | 2        | Creatine kinase, urea, haemoglobin, cholesterol, high density lipoprotein cholesterol, triglyceride, potassium, $\gamma$ -glutamyl transferase, alanine aminotransferase, aspartate aminotransferase  |
| Immunoassay system                                     | Vidas, France, BioMerieux Vitek, Inc   | 1        | Testosterone, cortisol, ferritin, hepatitis A antibody, hepatitis B surface antigen, hepatitis B surface antibody.  |
| Urine analyser   | Urisys 1100, Switzerland, Roche  | 2        | Urinary specific gravity, pH, leukocyte, nitrite, protein, glucose, ketones, urobilinogen, bilirubin, haematuria  |
| Osmometer  | The Advanced™ multi-sample osmometer, Model 2020, USA, Advanced Instruments, Inc | 1        | Plasma and urine osmolality.  |

## 4.B Sport Nutrition

As part of the Sport Nutrition Monitoring Centre, the function of the Sport Nutrition Unit is to monitor athletes' nutrition status and body composition, for example: weight, body fat, lean body mass, dietary intake and use of nutritional supplements, etc. In addition, the Unit also educates coaches and athletes regarding sport nutrition, so as to improve athletes' nutritional status and knowledge, thereby enhancing sports performance. The Sport Nutrition Unit analyses athletes' diets and designs individualised meal plans according to their sports, measures body composition (e.g. weight, height, skinfold, body fat and lean body mass, etc.), and provides nutritional advice for weight control, recovery, training, competition. Moreover, guidance on the use of supplements is also provided. The Unit also supervises athletes' foodservice which provides three meals and afternoon snacks, special arrangement can be made for athletes, e.g. in times of illness, late training sessions or pre-competition weight control. The Unit also develops educational pamphlets and delivers seminars and workshops for HKSI and community's coaches and athletes. In addition, the Sport Nutrition Unit continues to conduct applied research, mainly in the area of athletes' dietary intake, carbohydrates and hydration. The Sport Nutrition Unit also collaborates with other services, e.g. sports physiology, biochemistry, psychology, strength and conditioning and sports medicine in order to provide a more comprehensive support to athletes.

### SERVICE PROVISION

#### 1 Body composition measurement

Body fat percentage of typical Asian male is ranged from 14 to 23%, female from 17 to 27%. Athletes' percent body fat is often lower than the typical population, especially athletes in endurance sports, e.g. distance running, triathlon, road cycling, etc. Body fat level can directly affect their performance. For skilled sports, e.g. golf, bowling, shooting, archery, etc., the effect of body fatness to performance is not as direct. Moreover, body fatness is crucial to sports with weight categories, e.g. rowing, karatedo, windsurfing etc.

( Refer to **EQUIPMENT INVENTORY** for a detailed explanation of our body composition equipment: BIA Equipment: In Body 720 & DXA Equipment: Hologic Horizon Wi )

#### 2 Skinfold measurement

Skinfold measurement (Table 4.14) is a common method for determining body fat composition. Sports dietitians and nutritionists through measuring different standard anatomical sites around the body evaluate the changes of body composition by time. Since the accurate measurement technique is important, the sports dietitians and nutritionists received level 1 ISAK (The International Society for the Advancement of Kinanthropometry) training to measure athlete's body composition.


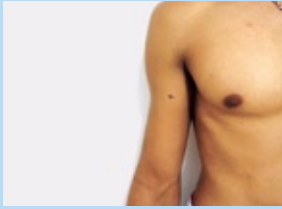
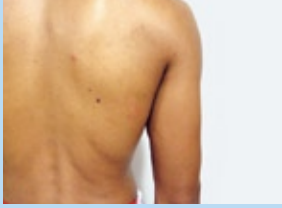

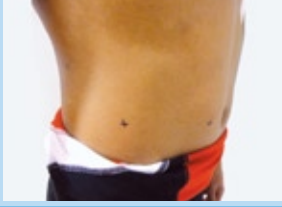
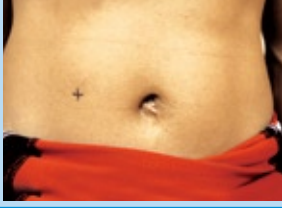
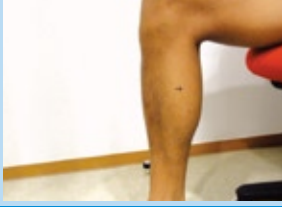

| Anatomical site | Location   | Picture   |
|-----------------|--|---|
| Triceps         | At the level of the mid-point between the acromiale (bony tip of shoulder) and the radiale, on the mid-line of the posterior surface of the arm  |    |
| Biceps          | At the level of the mid-point between the acromiale (bony tip of shoulder) and the radiale on the mid-line of the anterior surface of the arm  |    |
| Subscapular     | The lower angle of the scapula (bottom point of shoulder blade). Mark the location laterally downward at an angle 45°  |    |
| Iliac crest     | Immediately above the iliocristale (the most superior point on the iliac crest where the a line drawn from the middle of armpit)   |   |
| Supraspinale    | The intersection between the line from the marked iliospinale (the most inferior part of the tip of the anterior superior iliac spine) and the horizontal line at the level of the marked iliocristale |  |
| Abdominal       | The 5cm horizontally to the right hand side of the midpoint of the navel   |  |
| Medial calf     | The level of the maximum girth of medial (inside) of the calf  |  |
| Thigh           | The midpoint of a line between the patellare (the midpoint of the posterior superior border of the patella) and the inguinal fold  |  |

Table 4.14 Anatomical sites for skinfold measurement



Once skinfold thickness is collected, then it is converted into percent body fat by following equations (ACSM 2006):

*(Skinfold Measurement Equipment: Harpenden skinfold caliper)*

|   | <b>Male</b>  | <b>Female</b>   |
|---|--|---|
| Sites of measurement                            | Chest, abdomen, and thigh  | Triceps, suprailiac, and thigh  |
| Body density formula                            | $1.10938 - 0.0008267$<br>(sum of 3 skinfolds) +<br>$0.0000016$ (sum of 3<br>skinfolds) <sup>2</sup> - $0.0002574$<br>(age) | $1.099421 - 0.0009929$<br>(sum of 3 skinfolds) +<br>$0.0000023$ (sum of 3<br>skinfolds) <sup>2</sup> - $0.0001392$<br>(age) |
| Percentage of body fat formula (Asian-specific) | $4.97 / (\text{body density}) - 4.52$  | $4.76 / (\text{body density}) - 4.28$   |

### **3 Nutrient analysis**

Nutrient analysis is performed, by using software named The Food Processor SQL (ESHA Research, Inc), to assess the athletes’ diets, so that recommendations and meal plans for improvement of diet can be provided.

### **4 Seminars**

In order to let athletes understand proper nutrition, the Sport Nutrition Unit conducts seminars for coaches and athletes according to the needs of different sports on topics like hydration, advice on supplements, dietary advice, competition and training nutrition plans, etc. so that athletes can achieve optimal performance.

### **5 Pamphlets**

The Sport Nutrition Monitoring Centre develops educational pamphlets with a variety topic for all individuals who are interested. The topics of educational pamphlet are shown in Table 4.15.

| Sport Nutrition Education Series | Title   |
|----------------------------------|---|
| I                                | The Concept of Energy   |
| II                               | Guidelines to a Healthful Diet  |
| III                              | Learn More About Anaemia  |
| IV                               | Water – the Fountain of Life  |
| V                                | Maximize Your Energy Store for Competition                                  |
| VI                               | The Importance of Body Composition and Weight Control to Sports Performance |
| VII                              | Sport Nutrition for Young Athletes  |
| VIII                             | Alcohol – Effects on Sports Performance                                     |
| IX                               | Recovery Nutrition  |
| X                                | Squash  |
| XI                               | Tennis  |
| XII                              | Rowing  |
| XIII                             | Triathlon   |
| XIV                              | Nutritional Supplements for Athletes  |
| XV                               | Travel Nutrition  |
| XVI                              | Immunity and Nutrition  |
| XVII                             | Assessment and Treatment of Iron Depletion and Iron Deficiency in Athletes  |
| XVIII                            | Making Smart Choice with the Food Label                                     |
| XIX                              | The Champion's Cookbook   |

Table 4.15 The topics of educational pamphlet developed by the Sport Nutrition Monitoring Centre



Figure 4.1 A series of educational pamphlets developed by Sport Nutrition Monitoring Centre

## 6 Athletes' food service

The Sport Nutrition Unit provides recipes to and assists in menu planning with the Catering Department at the HKSI. Both parties work closely to monitor meal quality. Daily breakfast, lunch, dinner and afternoon snacks are served in buffet style. The main courses of lunch and dinner include high carbohydrate, high protein (western), high protein (chinese), contains iron and high energy choices. Soups, fresh milk, yogurt, vegetables (oil free and oil containing), fresh fruits, juices and desserts, etc. are also provided.



Figure 4.2 The Elite Corner provides a vast variety of food to serve our athletes in buffet style.

| 五穀類 Grains   |   | 蔬菜類 Vegetables  |  |
|--|---|---|--|
| 紅菜頭和南瓜沙律<br>Beetroot and Pumpkin Salad   |   |   |  |
| 營養素<br>Nutrient  | <br>1 碗 250 克<br>1 bowl 250 g | <br>每 100 克<br>Per 100 g |  |
| 熱量 (千卡)<br>Energy (kcal)   | 228.6   | 91.4  |  |
| 碳水化合物 (克)<br>Carbohydrates (g)   | 28.0  | 11.2  |  |
| 蛋白質 (克)<br>Protein (g)   | 5.0   | 2.0   |  |
| 脂肪 (克)<br>Fat (g)  | 10.7  | 4.3   |  |
| 鐵 (毫克)<br>Iron (mg)  | 1.7   | 0.7   |  |
| 鈣 (毫克)<br>Calcium (mg)   | 106.1   | 42.4  |  |
| 註：此食品含有核桃，對核桃敏感人士應避免進食。<br>Remarks: This food contains walnut. People who are allergic to walnut should avoid this dish. |   |   |  |

Figure 4.3 A nutrition card displays in front of each dish to provide nutrition information so that athletes can based on their requirements to make a correct choice.

## CASE STUDIES

### Nutrition consultation for a cyclist

An 18 year-old male full-time cyclist attended a nutrition consultation at the Sport Nutrition Monitoring Centre. The athlete trains six days per week and about four hours per day.

#### Body composition and biochemistry

| Body composition  | Biochemistry  |
|---|---|
| <ul style="list-style-type: none"> <li>Height: 173 cm</li> <li>Weight: 63 kg</li> <li>Fat mass: 8.3 kg (13.2% body fat)</li> <li>Lean body mass: 54.7 kg</li> </ul> | <ul style="list-style-type: none"> <li>Complete blood count: Normal</li> <li>CK: 250 U/L</li> <li>Urea: 52.7 mg/dL</li> </ul> |

#### Diet

|           |   |
|-----------|---|
| Breakfast | <ul style="list-style-type: none"> <li>Scrambled egg, sausage, ham 1 of each</li> <li>Chiffon cake 1 piece</li> <li>BBQ pork bun 2 pieces</li> <li>Low fat milk 1 cup</li> </ul>                                |
| Lunch     | <ul style="list-style-type: none"> <li>Rice 1 bowl</li> <li>Sparerib 1 oz</li> <li>Beef 3 oz</li> <li>Choy sum 100 g</li> <li>Jelly 125 ml</li> <li>Red bean dessert 1 bowl</li> <li>Soy milk 2 cups</li> </ul> |
| Dinner    | <ul style="list-style-type: none"> <li>Rice 1 bowl</li> <li>Kai Lan 100 g</li> <li>Chicken thigh without skin 10 oz</li> <li>Yoghurt 150 g</li> </ul>   |

| Energy    | Carbohydrate                                   | Protein   | Fat   |
|-----------|--|---|-------|
| 3248 kcal | 333 g or 5.3 g/kgBW<br>(ideal*: 8 - 12 g/kgBW) | 146 g or 2.3 g/kgBW<br>(ideal*: 1.6 - 1.7 g/kgBW) | 148 g |

\* Recommended intake is referred from Australian Institute of Sports

### Analysis

Athlete's body composition is ideal. However, his urea level is high indicating that the athlete either consumes an inadequate amount of carbohydrate or an excessive amount protein. According to the reported diet, the athlete consumes an inadequate amount of carbohydrate and an excessive amount of protein. Therefore, the suggested meal plan will increase the amount of carbohydrate intake and reduce protein consumption.

### Suggested meal plan

|               |   |
|---------------|---|
| Breakfast     | <ul style="list-style-type: none"> <li>• White bread 3 slices</li> <li>• Jam 3 tsp</li> <li>• Peanut butter 2 tsp</li> <li>• Low fat milk 1 cup</li> <li>• Boiled egg white 2 pieces</li> </ul> |
| Lunch         | <ul style="list-style-type: none"> <li>• Rice 2 bowls</li> <li>• Beef tenderloin 3 oz</li> <li>• Green vegetable 1 cup</li> <li>• Orange 1 piece</li> </ul>                                     |
| Afternoon Tea | <ul style="list-style-type: none"> <li>• White bread 1 slice</li> <li>• Jam 1 tsp</li> <li>• Banana 1 piece</li> </ul>  |
| Dinner        | <ul style="list-style-type: none"> <li>• Rice 3 bowls</li> <li>• Chicken 3 oz</li> <li>• Green vegetables 100g</li> <li>• Apple 1 piece</li> </ul>  |

2L sports drink per day

| Energy    | Carbohydrate        | Protein             | Fat  |
|-----------|---------------------|---------------------|------|
| 3784 kcal | 595 g or 9.4 g/kgBW | 106 g or 1.7 g/kgBW | 83 g |

After one week, the athlete's blood urea returned to 38.5 mg/dL.

### Nutrition consultation for a swimmer

A 19 year-old part-time male swimmer attended a nutrition consultation at the Sport Nutrition Monitoring Centre for a weight gain strategy. The athlete also reported feeling weak and fatigued. He trains five times per week, one hour in the morning and two hours in the afternoon.

*Body composition and biochemistry*

| Body composition   | Biochemistry  |
|--|---|
| <ul style="list-style-type: none"> <li>• Height: 170 cm</li> <li>• Weight: 56 kg</li> <li>• Fat mass: 4.6 kg (8.3% body fat)</li> <li>• Lean body mass: 51.4 kg</li> </ul> | <ul style="list-style-type: none"> <li>• Haemoglobin: 13.8 g/dL (13 - 17 g/dL)</li> <li>• Hameatocrit: 40.1% (40 - 50%)</li> <li>• Ferritin: 25.31 ng/ml (45 - 300 ng/ml)</li> <li>• Serum iron: 51.84 µg/dL (65 - 170 µg/dL)</li> <li>• Transferrin saturation: 13.17% (15 - 50%)</li> <li>• Urea: 37.8 mg/dL</li> </ul> |

*Diet*

|                   |   |
|-------------------|---|
| Breakfast         | <ul style="list-style-type: none"> <li>• Bread 2 slices</li> <li>• Peanut butter 1 tsp</li> <li>• Skimmed milk 1 cup</li> </ul>                             |
| Post AM training  | <ul style="list-style-type: none"> <li>• Bread 1 slice</li> <li>• Jam 1 tsp</li> </ul>  |
| Lunch             | <ul style="list-style-type: none"> <li>• Rice 1 bowl</li> <li>• Beef 3 oz</li> </ul>  |
| Before training   | <ul style="list-style-type: none"> <li>• Energy bar 1/2 piece</li> </ul>  |
| Post PM training  | <ul style="list-style-type: none"> <li>• Bread 1 slice</li> <li>• Jam 1 tsp</li> </ul>  |
| Dinner (8 - 9 pm) | <ul style="list-style-type: none"> <li>• Rice 2 bowls</li> <li>• Few pieces of vegetables</li> <li>• Chicken 6oz</li> <li>• Fruit (occasionally)</li> </ul> |

| Energy    | Carbohydrate  | Protein  | Fat  | Iron                            |
|-----------|---|--|------|---------------------------------|
| 2061 kcal | 260 g or<br>4.6 g/kgBW<br>(ideal*: 6 g-<br>10 g/kgBW) | 89 g or<br>1.6 g/kgBW<br>(ideal*: 1.6 g -<br>1.7 g/kgBW) | 75 g | 11.8 mg (12.5 mg <sup>3</sup> ) |

\* Recommended intake is referred from Australian Institute of Sports

<sup>3</sup> Recommended nutrients intakes (RNI) for Chinese aged 18 - 49

*Analysis*

This athlete should benefit from increasing lean body mass. The athlete complained about feeling weak and fatigue and this may be due to inadequate energy or carbohydrate intake as well as poor iron stores. Therefore the suggested meal plan will increase the amount of carbohydrate intake and include more iron rich foods.

### Suggested meal plan

|                  |  |
|------------------|--|
| Breakfast        | <ul style="list-style-type: none"> <li>• Corn flakes 1 cup</li> <li>• Whole milk 1 cup</li> </ul>  |
| Post AM training | <ul style="list-style-type: none"> <li>• Bread 2 pieces</li> <li>• Jam 2 tsp</li> <li>• Calcium-fortified soy milk 1 cup</li> </ul>                  |
| Lunch            | <ul style="list-style-type: none"> <li>• Rice 2 bowls</li> <li>• Beef 3 oz</li> <li>• Vegetable 1 bowl</li> <li>• Fruit 1 piece</li> </ul>           |
| Before training  | <ul style="list-style-type: none"> <li>• Energy bar 1 piece</li> </ul>   |
| Post PM training | <ul style="list-style-type: none"> <li>• Bread 2 slices</li> <li>• Jam 1 tsp</li> </ul>  |
| Dinner           | <ul style="list-style-type: none"> <li>• Rice 2 bowls</li> <li>• Vegetables 1 bowl</li> <li>• Chicken thigh 3 oz</li> <li>• Fruit 1 piece</li> </ul> |

| Energy    | Carbohydrate           | Protein               | Fat  | Iron  |
|-----------|------------------------|-----------------------|------|-------|
| 2581 kcal | 395 g or<br>7.0 g/kgBW | 95 g or<br>1.7 g/kgBW | 69 g | 32 mg |

### First Follow-up (One month after first interview)

|  |   |
|--|---|
| <ul style="list-style-type: none"> <li>• Weight: 58.2 kg</li> <li>• Fat mass: 4.9 kg (8.5% body fat)</li> <li>• Lean body mass: 53.3 kg</li> </ul> | <ul style="list-style-type: none"> <li>• Ferritin: 25.31 ng/ml → 28.33 ng/ml (improving trend)</li> <li>• Serum iron: 51.84 µg/dL → 99.24 µg/dL (within normal range)</li> <li>• Transferrin saturation: 13.17% → 24.34% (within normal range)</li> </ul> |
|--|---|

## Reference

ACSM (American College of Sports Medicine). (2006) *ACSM's Guidelines for Exercise Testing and Prescription*. 7th Edition, Lippincott Williams & Wilkins, Philadelphia.



## EQUIPMENT INVENTORY

| Equipment  | Brand & Model                                    | Quantity | Purpose of use   |
|--|--|----------|--|
| Bioelectric impedance analysis (BIA) equipment   | In-body 720                                      | 1        | Bioelectrical impedance analysis (BIA) is a relatively simple, quick and non-invasive technique, to measure body composition. BIA measures the resistance of body tissue to the flow of a small, harmless electrical signal. Since fat is a very poor conductor of electricity, a lot of fat will impede the current. By measuring the resistance to the current, the machine estimates the percent body fat.  |
| Dual-energy X-ray absorptiometry (DXA) equipment | Hologic Horizon Wi                               | 1        | Dual-energy absorptiometry (DXA), a technique that is widely used clinically to assess a patient's risk of osteoporosis and to monitor the effects of therapy. DXA is also increasingly used to measure body composition in terms of fat mass and lean body mass. DXA machine generates X-rays at two different energies and make use of the differential attenuation of the X-ray beam at these two energies to calculate the bone mineral content, fat mass and lean body mass in the scanned region.            |
| Skinfold measurement equipment                   | Harpender skinfold caliper                       | 1        | Skinfold measurement is a common method of estimation of body fat by skinfold thickness measurement. Measurement can use from 3 to 9 different standard anatomical sites around the body. The right side is usually only measured. The tester pinches the skin at the appropriate site to raise a double layer of skin and the underlying adipose tissue, but not the muscle. The calipers are then applied 1 cm below and at right angles to the pinch, and a reading in millimeters (mm) taken two seconds later |
| Hydration assessment equipment                   | Atago Urine Specific Gravity (USG) Refractometer | 2        | Urine specific gravity is a measure of the ratio of the density of urine to the density of water. The USG value is greater than 1.020 indicates dehydration  |

# CHAPTER 5

## SPORT PSYCHOLOGY CENTRE

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### Introduction

The Sport Psychology Centre is responsible for cooperating with coaches and facilitating athletes' performance in both training and competitions from a psychological perspective. The aim of the Centre is to develop a cutting-edge applied sport psychology service system with a comprehensive and holistic perspective of performance enhancement and all-around development of athletes. The objectives include:

- To cooperate with athletes and coaches in their endeavor in performance enhancement in competitive sport settings.
- To help athletes with their all-around development by transferring excellent characteristics and capabilities from sport to other life domains.
- To work together with colleagues from other sport sciences disciplines under an integrated multi-disciplinary model, and provide a comprehensive sport science service for athletes and coaches.

The form of the aforementioned sport psychology services includes individual and group counselling, psychological assessment, mental skills training, on-field support and applied research.

Sport psychology service highly depends on effective communication and task-oriented relationship. Evidence-based practice and individualisation are the most important principle of sport psychology interventions applied in the Centre.

## 5.A Sport Psychology

### SERVICE PROVISION

#### 1 Individual and group consultation

Sport psychology consultants in the Centre provide one-on-one counseling to athletes. Performance enhancement is the main goal and also the most common presenting issue in counselling sessions. Subdivided concerns include anxiety management, self-confidence, goal setting in competition and training, as well as concentration and refocus. Concerns affecting athletes' performance indirectly and often being brought in the sessions include relationship with coaches or teammates, personal and family relationship, school and examination pressure, and retirement and career planning.

As scientific-practitioners, sport psychology consultants employ evidence-based approach (e.g., cognitive behavioural therapy) in their counselling service. They also conduct applied research to further verify their services. In recent development, the Centre has been employing mindfulness approach in individual and group counselling sessions. Borrowing the well-studied concept of mindfulness from clinical and other professional settings, the Centre has developed sport-specific mindfulness intervention titled as "Mindfulness-Acceptance-Enlightenment-Commitment therapy" (Si, Zhang, Su, Zhang, Jiang, & Li, 2014). It highlights the aspect of concentration enhancement via the practice of "Here-and-now" focus and non-judgmental thinking. It can help athletes to clarify their life values so as to understand where they should focus at any given point of their career.

Sport psychology consultants would provide counselling in a group setting as well. Group counselling is likely to happen in team sports or team event of any individual sports. Apart from previous presenting issues, team dynamics and communication are the two most common concerns in group counselling.

When sport psychology consultants notice or are informed that athletes are experiencing clinical issues such as mood disorder or eating disorder, professional referral (i.e., medical, clinical psychology or psychiatry) will be given according to the ethical guidance and athletes' preference.

#### 2 Mental skills training

##### 2.1 Relaxation

###### *Objective*

Relaxation helps athletes to relax different muscle groups, calm down emotion and adjust arousal level of the central nervous system. It also helps to increase athletes' adaptability to stress.

###### *Methods*

- ***Breathing exercises***

Abdominal breathing, or diaphragmatic breathing helps to maximise the amount of oxygen that goes into the bloodstream by contracting the diaphragm while breathing. Air enters the lungs and the abdomen expands rather than the chest.

- ***Progressive muscle relaxation***

This systematic procedure aims to achieve a deep state of muscle relaxation by beginning with attention directed to the dominant parts and slowly shifts to the non-dominant parts across the body. For each part, the athlete is asked to feel the different feelings between the tension produced by contracting the specific muscles and the relaxation comes after releasing the contraction.

## 2.2 Imagery

### *Objective*

Using cue words and possibly all the senses to create or re-create specific moments and experience in the mind. “Seeing is Believing”, athletes can see and feel themselves achieving their goals which in turn giving rise to the sense of competence, increase self-confidence and decrease competitive anxiety.

### *Methods*

Both internal and external perspective can be used. An internal perspective suggests that the individual views oneself performing a task from own eyes whereas an external perspective is watching an image of oneself performing the task from outside. Use all the senses including visual, kinesthetic, auditory, tactile and olfactory to make images as vivid and detailed as possible. In addition, have a strong sense of controllability to manipulate the images so that they do what they want them to. Imagery can be used and practiced before and after training/competition, personal times and rehabilitation.

## 2.3 Concentration

### *Objective*

To increase athletes’ ability to focus on relevant and appropriate stimuli under certain circumstances and to shift focus of concentration in response to changing performance demands.

### *Methods*

- ***Attentional span and attentional direction***

Athletes need to be able to identify, engage in and shift between different types of concentration according to attentional span (broad and narrow) and attentional direction (external and internal). For example, an athlete first broadly runs through internal thoughts to develop a competition strategy. He or she then shifts attention to external elements such as the position of the opponent, or the features of the environment, and finally narrows attention to execute the game plan. The constant mental shifting from external to internal, broad to narrow allows athletes to choose and control what is important, stay focused upon it, and shift focus as needed.

- ***Cue statement/ focus word***

A cue statement or a focus word is a personal, positive and short statement said to oneself which helps to refocus concentration and stop negative and distracting thoughts. The ideal statement or word should be meaningful and believable. Whether it is a single word such as “focus” or a short personal statement such as “relax, breathe and focused”, it should not interfere with the necessary thoughts during performance.

## 2.4 Cognitive adjustment

### *Objective*

The assumption is that cognition, attitude and values affect a person's emotions and behaviours. The event itself is neutral, what influences a person's emotions and behaviours is the person's interpretation of the event. Thus, to change a person's emotion and behaviour, one has to change the way the person interprets the event. By adjusting athletes' negative and irrational thinking, their behaviours can be changed and thus leads to performance enhancement.

### *Methods*

- ***Emotional regulation***

Firstly identify the event that is related to the appearance of irrational emotions or behaviours and recognise the rational and irrational beliefs about the event. After disputing irrational beliefs and correcting cognitive errors, replace the irrational beliefs with rational and constructive ones.

- ***Self-talk***

Self-talk is verbalisations or statements addressed to the self. It is both instructional and motivational, and the use of positive, overt and freely determined self-talk helps to increase athletes' levels of intrinsic motivation.

## 2.5 Biofeedback training

### *Objective*

Biofeedback is a tool which immediately and continuously reflects a person's physiological signals by visual and auditory means. It allows athletes to control the functioning of their physiological processes.

### *Methods*

Biofeedback tools help to measure and record different physiological responses, including heart rate and heart rate variability, respiration rate, muscle activity using electromyograph (EMG), skin temperature, skin conductance, and brain wave activity frequency using electroencephalography (EEG). Sensors are attached to various locations on the athlete's body which allow them to send signals from the body to the computer to provide instant visual and auditory feedback on how the body is functioning under different circumstances. This feedback can be used to learn how to reach an ideal or desired state or to control undesired responses, such as rapid heart rate, shallow breathing, etc.

### 3 On-field support

It is a new trend that sport psychologists provide on-field support to sport team during major competitions in the field of sport science and competitive sports. According to an incomplete data, not only most of the sport advanced countries including American, UK, Germany, Australia, China, but also our Asian companions such as Japan, Korea, Taiwan, Singapore, Malaysia etc., will send their sport psychologists to provide sport psychology on-field support during major competitions. The contribution of these sport psychologists accept wide appreciation by coaches and athletes. In the past decades, sport psychologists in HKSI, upon the coaches' requests, provided on-field support to athletes at local/international competitions and overseas training camps. The following on-field support discussion is basically focused on international competitions.

#### 3.1 Prerequisites for on-field support

There is a controversial “hand-stick effect” of sport psychology service, which is saying that athletes should handle the pressure of major competitions independently and throw the “hand-stick” away once they become experienced and mature with the help of sport psychologist (Murphy, 1995). Although, the intensity and complication of stress in major competitions will crash any athlete in any seconds, making them feel overwhelming. As chief Sport Psychologist of the US team, Sean McCann said: At Olympics, everything is an issue (McCann, 2008). Generally speaking, a sport psychologist is just like the role of a family doctor, because an athlete really could use doctor's diagnosis and help when he or she is sick even though he or she has some basic medical knowledge.

To be effective, on-field support work should include the following:

- The establishment of good relationship with athletes prior to the provision of support.
- Adequate resources for the provision of overseas on-field support service.

#### 3.2 Principles of on-field support

On-field support work is based on a previously established solid foundation of good relationship with the sport team. It is only when there is sufficient mutual understanding and trust between the psychologist and athletes that effective support can be provided. The focus is on performance enhancement, in particular, to help athletes to handle their thoughts and emotions or other concerns properly.

#### 3.3 Function of on-field support

- **Enhance performance by eliminating or alleviating the athletes' concerns and worries (Case 1) :**

Fencing athlete C, he suddenly noted that his opponent in quarterfinal would be the same one who beat him last year. He worried the same thing would happen again and recalled the last experience spontaneously. The following is the conversation between C and our sport psychologist (P):



C: What a coincidence, him again!

P: What about him?

C: I lost to him last year, and the situation was passive. I am not able to cope with his style of playing, and I go blank in the last few round.

P: And you can still recall his playing style?

C: Of course, feel weird.

P: What kind of progress you have made this year?

C: I believe I have made much progress, especially in the attack skill, if I can do my best.

P: And do you know how to take advantage of you attack skill?

C: Yeah, I prepared well, just not for sure.

P: How about to review the win of your last matches in the elimination round?

C: Oh, OK, I get it, let me try.

In this case, the main strategy of sport psychologist is to lead the athlete to acquire the self-efficacy by replacing the failure experience with the feeling of success, and reappraisal of the match situation and his opponent. C won this match.

- **Increase the athletes' confidence and competitive spirit through consultation**

- (Case 2) :

Rowing athlete L competed in an international game, L became worried and caught a "cold feet". This was the first time for her to play the stroke seat, she feared that she could not bear this burden of the quadruple. Sport psychologist had a quick talk with her, and decided to use imagery technique to alter her mindset. Firstly, let her have several deep breaths slowly and count the number of it. It helped her to relax and redirect her attention to a neutral place. Secondly, sport psychologist guided her to imagine her victory one month ago in national competition, and emphasised her competence and confidence at that time. Last but not least, leading her to recall another successful match against the German team, a very strong and competitive opponent, and let her focus on the joy and satisfaction she ever had. The whole process took about 7-8 minutes. L said she was refreshed after opening her eyes.

In this case, sport psychologist used the cognitive code and emotion feeling of successful experience to repress and alter this kind of anxiety. L performed well in the competition and led the quadruple won the third place.

- **Provide catharsis especially after losing a match or facing acute stressor (Case 3) :**

Table tennis athlete D, a very talented but emotional athlete. She was very stressful and worried about the upcoming World Junior Championship, because she was the No.1 seed and she wanted to have a perfect ending of her junior stage game. Unfortunately, she did not play well and lost most of the team events even though coach and sport psychologist helped her stabilised her mood and prepared the game well. She burst into tears and ran out of the game stadium after she lost her point at quarterfinal of team event versus Germany. She was completely crashed, acted irrationally and dangerous. She jumped

into a fountain in front of the stadium to cool herself down, according to her own saying, in chill winter weather. This was a big emotional crisis of her, while catharsis was needed with tender attention. She really wanted to have some personal space and cry out release her pressure. Meanwhile, the sport psychologist must make sure she would not act dangerously again. Sport psychologist kept to her for a brisk walk away from the stadium (to a neutral environment) and let her calm down naturally, while did most of the listening not persuasion. Attention was needed but not too close. One session of consultation was arranged.

**P: Still sad and painful?**

**D: Yeah, a little bit, I still can't believe I played suck that much.**

**P: What happened exactly after you lost today?**

**D: I was so angry and disappointed and so I jumped into the fountain, I just wanted to cheer myself up and punish myself a little bit, but I acted totally irrationally and irresponsible.**

**P: How about now? What is your feeling now?**

**D: It couldn't be worse than today, I still got single and double event, so I will let all today's happening past behind. Just a little bit awkward when facing coaches and teammates.**

**P: Don't need to be, you just need to focus on your own performance and be true to yourself. I think you act you own true, and you will be more strong on the field of competition.**

In the single event, Player D stayed calm and concentrated, She lost quarterfinal to a Chinese player (tough opponent), but she felt that she had played her best and satisfied with her performance.

- **Improve the interaction between the coach and the athletes**

The relationship between coaches and coaches, coaches and athletes, athletes and athletes will be subtle and tense in the atmosphere of large competitions. They pursue the same goal of excellence and performance, but sometimes there are misunderstanding of each other. Another phenomenon is that one party may hold their string too hard and tight, the other party feels suffocated. And also they will have different opinion on technique, tactic, and other things related to competitions. All the problems above need more communication and interaction. Sport psychologist may act as a communication facilitator between them. But there are principles of communication need to bear in mind in the stressful atmosphere:

- Coaches and athletes must understand that the purpose of communication is to solve the problem, not to prove one's own good or other's bad.
- Coaches and athletes must separate the emotion and message in the communication process.
- The volume of message must be acceptable, simple and easy.
- The message must be clear, accurate and insightful, otherwise, it will cause more confusion.

### 3.4 The limitation of on-field support

On-field support cannot solve such basic problems of the athletes' motivation and personality. In addition, without fundamental training of mental skills, it will be difficult for the sport psychologist to teach the athletes these skills on-site.

- The role of the sport psychologist is that of a sport psychologist, no more or no less. The role should be clearly delineated from a coach, athlete, manager, or team medical staff. In addition, confidentiality should be strictly observed.
- The ultimate purpose of on-field support is for the athletes to become independent and be able to independently solve the problems which may arise at competitions.

## CASE STUDIES

### Application of cognitive restructuring, mental skills training and social support for a table tennis athlete

#### *Background*

The athlete was a world class table tennis athlete (doubles category). He strived for perfection in his techniques and would not tolerate any mistakes made by himself or his partner at competitions. He had frequent conflicts with his coach during practice and competitions, and showed strong emotions when encountering setbacks in competitions, and this usually resulted in poor performance.

#### *Objective*

Change irrational thoughts (i.e., perfectionistic), improve his behaviours and enhance his performance at competitions.

#### *Training method and procedure*

The training method was threefold:

- Counselling and cognitive restructuring – discussed with the athlete the concepts of rational and irrational beliefs and their differences, as well as the problems of perfectionistic thinking, using current events as examples to illustrate a more constructive way of thinking. Eventually, the athlete was able to accept the belief of “adversity is normal, and smoothness is exception.”
- Mental skill training – the training included systematic relaxation, imagery and self-talk. Once mastered, the skills could be applied in practice and competitions.
- Social support network – influenced the athlete positively by the consistency in the interaction of the coach, his partner and friends with him. Conjoint meetings between the athlete, coach and psychologist, or that between the athlete, partner and psychologist were held to discuss specific issues related to concurrent events.

The above mentioned intervention was integrated into the psychologist's consultation with the athlete at overseas training and competitions as well as in

HKSI, in particular, at “critical moments” when important events occurred. The intervention lasted for 18 months.

### Outcomes

- In 2004, slowly and gradually, the athlete became more rational in his thinking, stable in his behaviours, and more cooperative in his interaction with the coach. His performance was also enhanced, securing a position for the Hong Kong men’s doubles team at the World Championships, and a silver medal at the Olympic Games in the same year.
- Training in cognitive restructuring was a long-term process, with repeated use of multiple training methods.
- The coach was a determining factor in the success of mental skills training. While the coach could be a source of stress for the athletes, he could also be an important resources person for the athlete in the latter’s effort to cope with stress.

## EQUIPMENT INVENTORY

| Equipment                    | Brand & Model  | Quantity | Purpose of use  |
|------------------------------|--|----------|---|
| Reaction time test equipment | BD II-510A (China, Beijing University); Vienna Test System; and CATSYS System 2000   | 3        | <p>To test the speed and accuracy of the reaction to one stimulation signal (e.g., one-color light stimulation signal) in the Simple Reaction Time test.</p> <p>To test the speed and accuracy of the reaction to one stimulation signal that appears from four different stimulation signals (e.g., one light stimulation signal that randomly appears from four different colour lights) in the Discrimination Reaction Time test.</p> <p>To test the speed and accuracy of the reaction to four different stimulation signals, respectively (e.g., four different colour lights) in the Choice Reaction Time test.</p> |
| Concentration test equipment | BD II-510A (China, Beijing University); WT-Attention Test Computer Software (China, Wuhan Institute of Physical Education) | 2        | To test athletes’ ability to focus on one object for a certain period of time without distraction in the Concentration test.  |

| Equipment                         | Brand & Model   | Quantity | Purpose of use  |
|-----------------------------------|---|----------|---|
| Attention test equipment          | Vienna Test System  | 1        | To test the long-term selective attention and concentration ability, general performance and commitment in the Continuous Attention test.<br><br>To test the visual orientation performance for simple structures in a complex environment in the Selective Attention test. |
| Field dependence test equipment   | Rod Frame Apparatus (BD II-510A, China, Beijing University); Gestalt Perception test (Vienna Test System) | 2        | To test athletes' field independence and dependence (whether the athletes are easily affected by the circumstance or not) in the Field Dependence test.   |
| Coordination test equipment       | Vienna Test System  | 1        | To test the coordination of eye-hand, hand-hand, or eye-hand-foot in the Sensomotor Coordination test.<br><br>To test the visual-motor coordination (eye-hand and hand-hand coordination) in the Two-hand Coordination test.  |
| Sensory perception test equipment | Vienna Test System  | 1        | To test the ability to measure speed and movement in space in the Time-Movement Anticipation test.<br><br>To test the perception and processing of peripheral visual information in the Peripheral Perception test.   |
| Vigilance test equipment          | Vienna Test System  | 1        | To test athletes' attention under continuous stress in the form of sustained vigilance in the Vigilance test.   |
| Determination test equipment      | Vienna Test System  | 1        | To test reactive stress tolerance, attention deficits and reaction speed in the presence of rapidly changing and continuous optical and acoustic stimuli in the Determination test.   |
| Postural stability test equipment | CATSYS System 2000  | 1        | To test the ability of athletes to maintain the position of the body in the Postural Stability test.  |
| Mental fatigue test equipment     | Flicker Fusion Frequency Apparatus (LD3, China, Beijing University); Vienna Test System                   | 2        | To test the level of athletes' mental fatigue under specific conditions (i.e., before or after training or competition) in the Mental Fatigue test.   |

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# CHAPTER 6

## SPORTS MEDICINE CENTRE

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### Introduction

The Sports Medicine Centre strives to provide athletes with the best possible sports health care throughout their stay at the HKSI. The Centre is dedicated to the care, injury prevention and rehabilitation, diagnosis, treatment as well as the medical conditions of athletes.

The Centre provides a spectrum of medical supports for athletes, including physical examination, clinic services, orthopaedic consultations, physiotherapy, Chinese medicine, Chinese manual therapy, rehabilitative training, recovery enhancement, therapeutic exercise and sports massage, so that athletes can receive treatments promptly and return to their optimal states through various rehabilitative training. The Centre also provides athletes with regular musculo-skeletal evaluations, postural and movement impairment assessment for sports activities, and training sessions for enhanced flexibility, and shoulder and core stability. Other services include on-field support, doping control and education contributions.

The Centre works in a coordinated manner with the other sports science centres to provide the best medical support for our athletes. Besides, the Centre maintains close collaborative relationship with local and Mainland counterparts to enhance service level.



## 6.A Clinic, Nursing and Annual Check-up

### 1. General medical consultation

One of the major services provided by the Centre is the HKSI clinic. The clinic's medical in-charge looks after the clinical problems of athletes. Athletes who have any clinical discomfort or injury can make appointment to attend the clinic. The medical in-charge also conducts the Annual Medical Screening Exercise. The clinic opens four days a week on Monday, Tuesday, Thursday and Friday afternoon.

### 2. Orthopaedics consultation

The Centre also runs an orthopaedic clinic operated by experienced sports orthopaedic surgeons. They are responsible for athletes suffering from acute traumatic injuries and/or athletes with musculo-skeletal deficit. Not only do they make clinical diagnosis for the injured athletes, more importantly, they design specific and tailor-made treatment procedures and rehabilitation plans for the athletes together with the coaches and other paramedical professionals. The orthopaedic clinic runs twice weekly.

### 3. Nursing care

Nursing care is another important component of the HKSI clinic. The service includes immunization injections such as Hepatitis injection, and Flu prevention injections, taking care all the wound injuries of athletes such as antiseptic cleansing of open wounds and application of dressings to cuts and abrasions, supporting the Annual Medical Screening Exercise, and offer health education to our athletes.



*Figure 6.1 The athlete consults the clinic's medical in-charge.*



*Figure 6.2 Orthopaedic consultation provided by the visiting orthopaedic surgeons*



*Figure 6.3 The visiting orthopedic surgeon is assessing the injured athlete.*

#### **4. Annual Medical Screening Exercise**

The annual medical screening process generally starts in February each year. The screening will be conducted in two parts: physical assessment, and medical consultation. The physical assessment includes blood and urine sampling for laboratory examination. The medical consultation includes answering of questionnaires, checking of blood pressure, clinical examination and physical inspection, and interpretation of blood and urine test results. The medical-in-charge of the HKSI clinic will issue an official document upon satisfactory results indicating the suitability of being an athlete of the HKSI.



*Figure 6.4 Blood sampling for annual medical screening*

## 6.B Sports Physiotherapy

Sports physiotherapy serves a dual function in sports injury prevention and rehabilitation. Musculoskeletal screening, neuromuscular assessment and qualitative motion analysis are some of the means we adopt for establishment of injury prevention programme. As with other sports medicine clinics, the sport physiotherapists provide rehabilitation and treatment intervention in the form of electrotherapy, taping and bandaging, as well as manual and manipulative therapy. Therapeutic exercise programmes are condition-focused, sport-specific and targeting the neuromuscular control component for sustained improvement and long-term success in rehabilitation. For athletes with running-related injuries, running mechanics assessment is conducted. Specific custom-made orthotics may be fabricated for correction in some cases. As proper neuromuscular control with optimal timing and sequencing is of paramount importance both in injury prevention and as a functional goal in sports rehabilitation, we have also incorporated real-time ultrasound, clinical electromyography and qualitative video motion analysis in our clinical practice. Table 6.1 summaries the assessment and treatment activities for injury prevention and rehabilitation at the Centre and will be elaborated further in the following sections.

| Injury Prevention  | Injury Rehabilitation   |
|--|---|
| <ul style="list-style-type: none"> <li>• Musculoskeletal screening</li> <li>• Neuromuscular control assessment</li> <li>• Running biomechanics assessment</li> <li>• Qualitative analysis of sports motions</li> </ul> | <ul style="list-style-type: none"> <li>• Electrophysical agents</li> <li>• Manual and manipulative therapy</li> <li>• Taping and bandaging</li> <li>• Neuromuscular training</li> </ul> |

*Table 6.1 Assessment and treatment activities for injury prevention and rehabilitation*

### 1 Injury prevention

#### 1.1 Musculoskeletal screening (MSS)

There are several goals that MSS aim to achieve: a) fulfill the HKSI's legal and insurance requirements, b) assure the coaches that team members would start the season with some common level of health and fitness, c) provide the medical team with the opportunity to discover treatable conditions that might interfere with or be worsened by athletic participation, d) aid in predicting/preventing future injuries, and e) MSS would be appropriate for all sports.

MSS is one of the domains of physiotherapist in sports injury prevention and rehabilitation. The examination findings that should alert the physiotherapist to instigate further management procedures are those that indicated abnormalities of the articular, muscular and neurological systems. MSS employs both history and physical examination, they have to be interpreted together. It has been suggested that a complete history would identify approximately 75% of problems that affect athletes. Therefore if a problem surfaces on the history, the athlete will need to be singled out for direct examination. Likewise, if a significant abnormality is found on the physical examination, a more focused evaluation and perhaps a more detailed history should be sought.

Components of a typical MSS examination should include the following:

- The previous/present injury history including time, mechanism, investigation done, post-injury management, operation done etc.
- General musculoskeletal system assessment including posture assessment (any mechanical alignment problem), the joint system, range of motion, flexibility of muscle and muscle power assessment.
- Biomechanical assessment including lower limb biomechanics, upper limb biomechanics.
- Neuro-muscular control assessment including static strength tests of stability muscle (e.g. gluteus maximus, gluteus medius etc.), McGill back muscle endurance tests, proprioception etc.
- Specific orthopaedic tests: ligamentous stability, Neer's impingement test, overuse syndromes (ankle impingement, elbow lateral epicondylitis etc.).

Every effort has been made to put the most relevant assessment with evidence-based clinical reference for different sports at the HKSI. We believe the current approach provides a means for us to intercept injuries by modifying some of the known physical impairments that can be amended by physical conditioning and strengthening programme.

## 1.2 Neuromuscular control assessment

Low back pain, one of the most commonly seen musculoskeletal problems in our sports medicine practice, will be used as an example in the following discussion regarding neuromuscular control assessment.

All the muscles of the lumbo-pelvic region are capable of providing some support for the lumbar vertebral column as well as the sacroiliac joints. The muscles in this specific region generally fall into one of two muscle categories in terms of their functional role for stabilisation. Two muscle systems linked to stabilisation of the lumbar spine are the local muscle system and the global muscle system.

The muscles of the local system are closely related anatomically to the individual vertebrae and are capable of increasing spinal segmental stiffness and providing segmental support (Crisco, Panjabi, 1994). Both the transverse abdominis and multifidus belong to this category. The global muscle system comprises the larger torque-producing muscles, which are anatomically more remote from the lumbar vertebral joints. They function to control spinal orientation and to balance the external load placed on the spine. Rectus abdominis and the external oblique muscles are examples in this category.

Low back pain patients demonstrate specific coordination and control deficits in the local muscle system. These deficits include:

- Loss of anticipatory function
- Loss of ability to function independently of the other trunk muscles
- Delays in activation and thus a loss of preprogrammed function for support

- Asymmetric timing between the two sides of transverse abdominis, lessening its mechanical mechanism for support
- Lumbar multifidus inhibition in an acute episode of low back pain
- Phasic activity rather than tonic supporting contraction

*Methods commonly used to measure and quantify muscle strength (Richardson, Jull, Hides, 2000)*

#### **a. Measurement of the local muscle system**

As the key muscles of the local muscle system of interest are deep and not readily accessible. The measures required are ones that can reflect properties of motor control, not of the conventional parameters of muscle strength, endurance, or extensibility. In clinical practice, the measurement should ideally be convenient, comfortable to the patient, easy to apply and require minimal advanced skill training. Real time ultrasound imaging allows direct visualisation of the contraction of the deep muscles, both of the abdominal wall and of the fascicles of the segmental multifidus during an attempt to draw in the abdominal wall.



*Figure 6.5 Using real time ultrasound imaging to assess activation pattern of abdominal muscle including external oblique, internal oblique and transverse abdominus*

#### **b. Measurement of the global muscle system**

Surface EMG can be applied to most trunk muscles. In order to assess the level of activation and timing on activation, surface EMG is used to monitor muscles of the external oblique, internal oblique, and the rectus abdominus. In assessing the back muscle, the erector spinae in the low thoracic, thoraco-lumbo region could be monitored for over-demand activity.

Various types of data can be gathered to obtain information on the global muscle to help detect whether their activity is a reflection of over-demanded and impaired motor control strategies. These include the following:

- Level of contribution (percentage) to a standard test.
- Degree of co-contraction in a standard test. Clinical evidence of the poor global muscle patterns is often reflected in an increased co-contraction of the trunk flexor and extensor muscle groups beyond demand.
- Temporal pattern of the global muscle in a standard test. Problems in motor control may be detected by findings that muscles of the global system are recruited earlier than required or do not “turn off” in an appropriate time period following cessation of the test.



### 1.3 Running biomechanics assessment

Similar to all other sports activity, running activity has been associated with an increase in the number of injuries. Biomechanical evaluation of running has the potential to identify risk factors and contribute to prevention of running injuries. The identification of aberrant joint motion during gait is difficult and requires a developed observational skill, and if possible, the assistance of a digital video camera for motion capturing and slow motion playback. It is important to observe gait for any deviation from the ideal pattern of motion. Sagittal, coronal planes are easily captured in clinical setting and their motion analysis has been intensively studied in various literatures. There are three main biomechanical abnormalities affecting the lower limb: excessive pronation, excessive supination and abnormal pelvic movement.



*Figure 6.6 Excessive pronation in running*

*Figure 6.7 Excessive supination in running*

*Figure 6.8 Excessive pelvic tilting in running*

#### *Foot orthosis prescription*

The first element is the identification, verification and quantification of physical tasks that serve as the athlete's specific outcome measures. The second element is the application of strapping tape or Orthopaedic felt during the performance of these physical tasks. Anecdotal evidence suggests that the likelihood of success with subsequent application of an orthotics is probably greatest if the improvement in the quantity of physical activity is in the order of 75% of baseline or higher. Any 50% change from baseline level would also be likely to be having a lower level of success with any subsequent application of orthotics. With such guidelines for orthotics prescription and application, the chance of success of foot orthotics in alleviating athlete's symptoms can be predicted. Together with other findings on physical examination, such as muscle tightness and weakness, reduced motion of talo-crual, sub-talar and metatarsal-phalangeal joints should also be addressed once the effect of the orthotics has been ascertained. From our clinical experience, full amelioration of all symptoms occurs only after selective application of exercises and manual therapy are used in conjunction with orthotics therapy.



## 1.4 Qualitative analysis of sports motion

Qualitative motion analysis is commonly used to evaluate specific motion for injury prevention purpose. It is by nature a subjective process but this does not mean it is unorganised or vague. On the contrary, qualitative analysis requires extensive planning, information from many disciplines and systematic steps. It also requires the integration of knowledge from biomechanics, pedagogy, motor development and motor learning.

### *Integrated model of qualitative analysis*

A simple four tasks model (Figure 6.9) proposed by Knudson and Morrison (2002) is described here to show each part of the integration for an effective analysis.

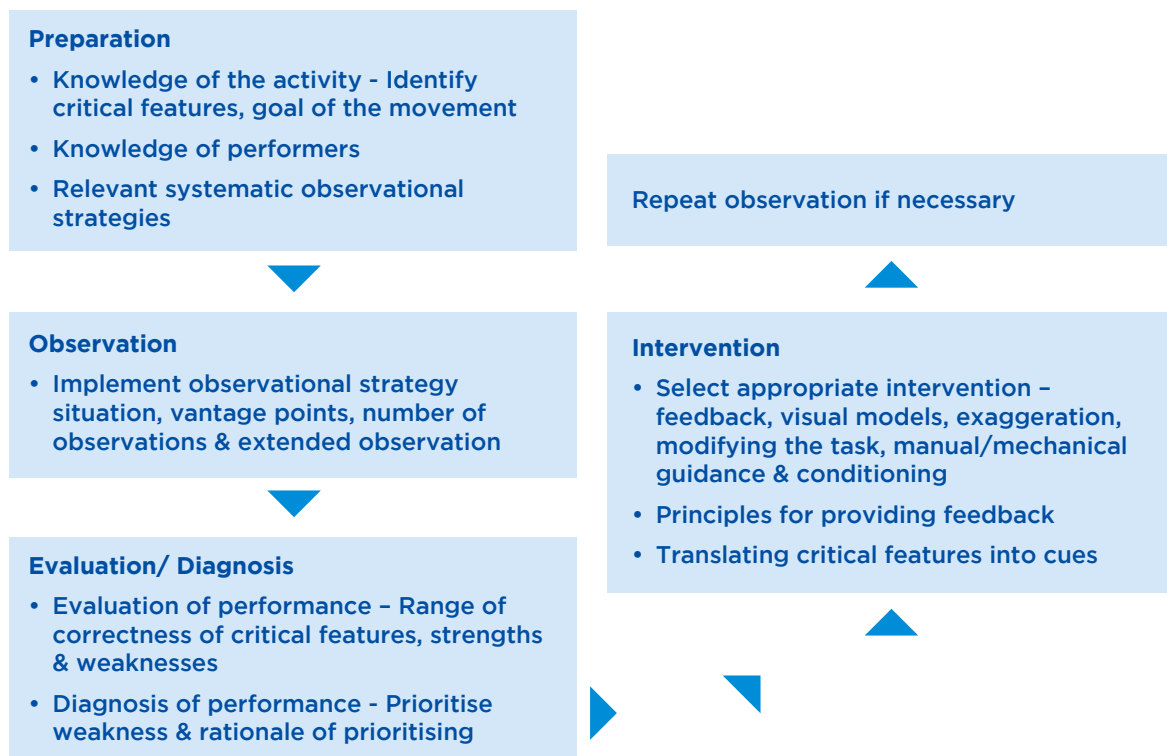


Figure 6.9 Four tasks model

### *Clinical applications*

In our clinical practice, we videotape the sporting motions with a digital videocamera and then analyse with commercial motion analysis software (SiliconCOACH – Sports/Pro Version 6, Dunedin, New Zealand). The aims of qualitative motion analysis are 1) to identify risk factor as a prevention strategy and 2) to provide information for intervention in rehabilitation, and ultimately to improve the overall sports performance. The essential areas described by Knudson and Morrison (2002) during visual evaluation are shown in Table 7.3.

**Movement simplification**

1. Observe slower moving parts
2. Observe separate components of complicated skills
3. Observe the timing of performance components

**Balance and stability**

4. Look at supporting parts of the body
5. Look at the height of the body and body part
6. Look at the foot and body positioning

**Movement relationship**

7. Look for unnecessary / trick movement
8. Look for movement opposition
9. Observe motion and direction of swinging body parts
10. Look at the motion of head
11. Note the location and direction of applied force

*Table 6.2 Essential areas in visual evaluation*

Here is one example of how the qualitative analysis is used at the HKSI. A tri-athlete complains of bilateral knee and foot pain after running for 5 km. Her coach also noticed she has problem in swinging her arm symmetrically. A qualitative analysis was carried out to evaluate her specific complaints.

We conducted a running assessment and the results showed that she has abnormal lower limb biomechanics, which may contribute to the existing problems. This included excessive pronation of bilateral feet during stance phase, limited hip extension from mid stance to toes off, excessive translation at lumbo-pelvic region, and reduced mid-thoracic left rotation range. Further physical examination appeared to correlate with the specific observational findings.

Pronation of foot occurs at the subtalar joint. Excessive pronation causes increased ground reaction forces on the medial aspect of the foot, and leading to the flattening of the medial longitudinal arch and increased strain on the plantar fascia and plantar musculature. This is accentuated when the foot remains pronated through heel-lift and toes off (Brukner & Khan, 2000). Excessive pronation also increases the internal rotation of tibia and may change the alignment of patellar tendon. This may predispose the knee for patella tendonopathy and patellofemoral joint dysfunction. Her limited hip extension and the increased translation of lumbo-pelvic region may be correlated with muscle imbalance and fair core stability issue. With the tightness of hip flexor and the fair pelvic control, this may decrease the dissociation between hip extension from pelvic movement during running. The limited mid thoracic left rotation range is compensated by excessive left shoulder extension and excessive lumbar rotation that may further aggravate the already increased lumbo-pelvic translation.

Subsequent intervention included orthotics to improve the foot positioning during running, regular stretching programme with emphasis on hip flexor, knee motor control training and therapeutic core stability exercises. Satisfactory improvement was noted after 4 weeks of intervention with minimal pain at bilateral knees, decreased translation of lumbo-pelvic region, better push off and overall better performance during running.

## **2 Injury rehabilitation**

### **2.1 Electrophysical agents**

Electro-physical agents have been frequently and widely used in physiotherapy practice from the early professional time. Despite their long history of utilisation, the underlying physical and physiological principles are still not clearly understood.

#### *Cryotherapy*

The application of ice and compression for management of acute soft tissue injuries is a commonly adopted approach in sports medicine. Ice changes the skin, subcutaneous, intramuscular and joint temperature of the applied region. Vasoconstriction occurs as a result of decreased tissue temperature, and this reduces the swelling associated with bleeding and inflammation. Decreased local metabolism is followed with a reduction of metabolites, and therefore limiting the extent of injury. A tissue temperature reduction of less than 15°C is optimal for decreasing metabolism without causing cell damage (Auley, 2001).

The motor and sensory nerve conduction velocity is decreased with cooling, followed by a decrease in the rate of firing of muscle spindle afferent and stretch reflex response, a decrease in acetylcholine level and therefore, a decrease in pain and muscle spasm. Although the duration and frequency of applying ice vary in clinical practice, an intermittent 10-minute ice treatment has been shown to be effective at cooling injured animal and healthy human tissues. There are different forms of ice application, and safety precautions need to be made at all times to prevent ice burn, skin allergy and open wound infection.

#### *Superficial heat*

Superficial heat is commonly used to treat soft tissue injuries for pain reduction and promotion of healing. Therapeutic effect is achieved when the tissue temperature is obtained between 40° to 45°C (Kitchen, 2002). This causes vasodilatation and cell metabolism enhancement, which may further promote tissue repairing. The increased blood flow also stimulates cutaneous heat receptors and produces pain relieving effect via the spinal segmental mechanism. With the reduction of pain in muscles, muscle spasm is reduced. Superficial heat has also shown to increase the extensibility of collagen tissue, and improve joint mobility (Kitchen, 2002). There is also well known psychological effect of superficial heat to give the feeling of relaxation, warmth and sedation. Superficial heat can be applied in many different ways, including hydrocollated pad, electrically heated pads, warm bath and wax. Although there is relatively few studies reviewing the optimal frequency and duration of applying superficial heat, the general consensus appears to be around 15-20 minutes. Before applying this modality of treatment, the risk of burn and the contraindications need to be considered.

### *Electrotherapy modalities*

Two types of electrotherapy modalities will be considered here because of their popularity in the treatment of musculoskeletal injuries. They are also used quite extensively in sports injury management at the HKSI.

#### **a. Ultrasound (US)**

Ultrasound machine generates a sound wave commonly at either 1 or 3 MHz. Treatment intensity varies from 0.5-3 W/cm<sup>2</sup>. Application of US to the injured tissue during inflammation would enhance the absorption process of various ions (Kitchen, 2002), and facilitate the injured tissue to move into their next phase of tissue healing (i.e. proliferation). Therefore, US acts as a pro-inflammatory mediator rather than an anti-inflammatory treatment. When applied during the proliferation phase, it stimulates the fibroblastic and endothelial cell activity. At the later stage of repair, US also appears to facilitate the remodeling phase. US has been reported to be effective for a variety of painful conditions and for neurogenic pain.

#### **b. Interferential Therapy (IFT)**

Interferential therapy is the use of applying two medium frequency currents (usually approximately 4,000 and 4,200Hz) to produce a modulated range of low frequency deep within the target tissue (adjustable between 0 and 200-250Hz). The lower frequency (<10Hz) is used for the treatment of chronic pain and higher frequency (>100Hz) is used for treating acute or subacute pain. IFT is proposed to stimulate the descending control system to suppress pain in lower frequency range and achieve segmental inhibition to reduce pain in higher frequency. The addition of rhythmically suction electrode produces a 'massage-like' effect, which may stimulate large-diameter afferents to enhance the inhibitory effects at spinal segmental levels.

## **2.2 Manual and manipulative therapy**

Manual and manipulative therapy (MMT) relies significantly on the accuracy and the clinical reasoning from the physical examination. Physiotherapists often hypothesise the athlete's problem through subjective questioning, and then confirm the provisional diagnosis through physical examination, which includes observation, palpation, standard and combined movements, functional activities, passive accessory intervertebral movement (PAIVM) (Figure 6.10) passive physiological intervertebral movement (PPIVM) (Figure 6.11) specific muscles function testing, neural tissue and/ or neurological examination. If "red-flagged" warning signs (such as recent weight loss, constant pain irrelevant to mechanical stress) are found, the athlete would be referred promptly to the medical consultant for further investigation. If there is no contraindication and the condition deemed appropriate for MMT, specific MMT techniques are implemented. An essential component of all MMT is to assess pain and restriction of movement immediately before and after each specific treatment technique so as to evaluate its treatment efficacy.



*Figure 6.10 Postero-anterior central vertebral pressure on L4. It can be regarded as an assessment or treatment (mobilisation) technique.*



*Figure 6.11 Passive physiological rotation of L3/4 & L4/5*



*Figure 6.12 Acupressure (deep thumb kneading) at UB52*

### *Soft tissue techniques*

These techniques enhance muscle relaxation, flexibility, and circulation of body fluids. The focus is primarily on restoring physiologic movements to altered joint mechanics. Techniques include sports massage, deep friction massage, myofascial release, strain-counterstrain, acupressure (Figure 6.12) and many more.



### *Mobilisation techniques*

In these techniques, the joint is gently carried repeatedly and passively in oscillatory movements. The purposes are to decrease pain and to increase the range of motion (ROM) in a stiff/ hypomobile joint where the normal motion has been restricted. The joint can be mobilised in a physiological ROM or accessory gliding. Mulligan (1999), developed a unique concept of combining passive accessory gliding with active physiological movement described as “Mobilisations with Movement” (MWM) for peripheral joints and “Sustained Natural Apophyseal Glides” (SNAGS) for intervertebral joints (Figure 6.13).

### *Manipulation techniques*

Manipulation is a sudden movement or thrust of small amplitude performed at high velocity at end of joint ROM. It is performed primarily at the intervertebral joints but may also be performed at the peripheral joints. Manipulation is same as mobilisation techniques, its purpose is to decrease pain and increase the range of motion (ROM) in a stiff/ hypomobile joint. Manipulation can be a very effective method of treatment. It is, however, associated with considerable risks if performed inappropriately or with poor handling skills and should only be performed by a fully qualified physiotherapist who has had formal training in manipulation.

### *Neural tissue treatment techniques*

Elvey & Hall (2004) described that in such techniques, the anatomic tissues or structures surrounding the affected neural tissue are gently mobilised with controlled and gentle oscillatory movement (Figure 6.14). It is indicated when the physical examination demonstrates that the neural tissue is the origin of the subjective complaint of pain. The clinical signs include active and passive movement dysfunction, adverse responses to neural tissue provocation tests, and hyperalgesic responses to palpation of nerve trunk and/or cutaneous tissues.



*Figure 6.13 SNAGS C4/5 in left rotation*



*Figure 6.14 Right lateral glide of C5 on C6 with gentle and controlled oscillation*



*Figure 6.15 Examples of various taping and bandaging materials*



## 2.3 Taping and bandaging

Taping and bandaging techniques are used extensively as one of the various adjuncts in the overall rehabilitation regime for sporting injuries and dysfunctions. Bandaging is usually used for immediate first aid for compression and support of the injured parts. Taping may be used for protection from injury, restriction of movement for an unstable joint, improvement of faulty biomechanics, unloading of painful structures, thus improving muscle function, and restoring functional movement patterns.

### *Immediate first aid (Compression and protection)*

Bandage is usually used in first aid. Ankle bandaging with elastic bandage for an acute ankle sprain is a common procedure in on-field sports medicine. The purpose is to support the ankle joint in a comfortable position and provide compression. The additional “J” shaped foam can be used to further compress the swelling over the retro-malleolar region.

### *Restriction of movement*

The classical example is the prophylactic ankle taping (Figure 6.16) for inversion ankle sprain. The function is to restrict excessive ankle inversion, while allowing normal ankle dorsiflexion and plantar flexion for sporting activities. Restriction of the ankle joint range of motion (ROM) represents the quantity of stability provided by each application.



*Figure 6.16 Prophylactic ankle taping with rigid tape*

### *Unloading painful structures*

The infrapatellar fat pad is one of the most pain-sensitive structures in the knee. With acute fat pad irritation, the pain is exacerbated by extension maneuvers such as straight-leg raises and prolonged standing. It is described that the tape needs to commence at tibial tuberosity, coming wide out to the medial and lateral joint line. The soft tissue needs to be lifted towards the patella.

Another example is the use of a diamond tape technique on chronic lateral epicondylalgia.



*Figure 6.17 KT for patella tendon support*

### *Improvement of faulty biomechanics and related neuromuscular changes*

During gait, a foot with excessive pronation of the subtalar and midtarsal joints will result in a flattening or loss of the medial longitudinal arch for a prolonged period of time. These biomechanical changes can lead to a reduction in stability of the foot and faulty alignment with stress to the joints above the kinetic chain including knee, hip, sacroiliac joint and/or even lower lumbar region. The low-dye taping significantly decreases the amount of pronation by altering the plantar pressure towards the lateral midfoot and toes.

Jenny McConnell (1986), had described that taping would correct patellar malalignment noted on the assessment of patella position, thus centralising it within the trochlea groove and improving patellar tracking (Figure 6.18). The shoulder, like the patellofemoral joint, is a soft-tissue joint whereby its position is controlled by the soft tissues around it. Poor muscle function, particularly around the scapula (especially subscapularis muscle), and chronic anterior instability may increase the translation of the humeral head in an anterior direction and narrow the subacromial space. The aim of the tape is to lift the anterior aspect of the humeral head up and back (Figure 6.19) (McConnell, 2004).



*Figure 6.18 McConnell patella taping*



*Figure 6.19 Relocation of the humeral head*

## **2.4 Neuromuscular training**

As part of a comprehensive rehabilitation programme, neuromuscular training with multiple components has been utilised extensively in physiotherapy. It is a logical sequence of progression of a series of exercises aiming to improve biomechanics of body segments, dynamic balance and posture, agility, speed strength (i.e. power) and for injury prevention in sport-specific activities.

The current concept regarding the design of neuromuscular training programme support the inclusion of the following components: resistance training, plyometric and technique training, proprioceptive and balance training, sport-specific training, education and enforced awareness of dangerous positions and mechanisms of injuries.

Proprioceptive and neuromuscular control deficits exist after anterior cruciate ligament rupture and well into the postoperative rehabilitation period. It can be inferred that these deficits may also present in a wide variety of athletic injuries of the musculoskeletal system and would equally benefit from neuromuscular training. Neuromuscular training aims to improve neural efficiency and sensitivity, and to increase functional joint stability. It is generally performed in rehabilitation of the injured athletes and also in injury prevention programme for the uninjured but at-risk athletic population.

Currently at the HKSI, neuromuscular training is usually conducted as part of the rehabilitation programme for our injured athletes to reestablish proprioception and neuromuscular control. It is a 3-phase process and progresses from static stabilisation, to dynamic stabilisation and finally to reactive neuromuscular control phases (Voight & Cook, 1996; Voight, Hoogenboom, Blackburn & Cook, 2004).

*First phase*

The rehabilitation goals of this phase are to restore normal mobility, diminish pain and inflammation, develop static control and posture, establish muscle balance and to improve the proprioceptive and kinesthetic awareness of the neuromuscular system. Proprioceptive Neuromuscular Facilitation (PNF) techniques such as Rhythmic Stabilisation (RS), Alternating Isometrics (AI) and Shortened-Held Resistance Contraction (SHRC) can be used in a weight-bearing or non-weight-bearing position based on the amount of tissue reactivity.



*Figure 6.20 Eccentric strengthening exercise for hamstrings*



*Figure 6.21 Lateral stability exercise with Dynamic Edge® slider*

### *Second phase*

The goals are to enhance dynamic functional stability, reestablish neuromuscular control and to restore normal muscular balance and motion. Exercises adopting the principle of Oscillating Techniques for Isometric Stabilisation (OTIS) and Impulse Techniques for Isometric Stabilisation (ITIS) can be prescribed for the lower extremities; and PNF techniques such as Slow Reversal Hold (SRH), Slow Reversal (SR) and Agonist Reversals (AR) for the upper extremities.

### *Third phase*

This is the final stage of neuromuscular training. The rehabilitation goals at this time are to improve reactive neuromuscular abilities, enhance dynamic stability, power and endurance. It is at this stage that we are preparing the athlete to return to his/ her former athletic activities such as throwing, running, jumping or cutting essential for most advanced sport functions. The

exercise programme includes a wide variety of plyometrics, multidirectional training and agility training. At the HKSI, we used a wide variety of equipment singly or in combination to accomplish the rehabilitation goals, including but not limited to, balance board, dynamdisc, foam rollers, BAPS, perturbation board, treadmill, SciFit® elipitical walker, Dynamic Edge® slider, TerapiMaster system, rebounder, BOSU (both sides up), body blade and pyloballs.



*Figure 6.22 Cardiovascular training with SciFit® elipitical walker*

### 3 Sport physiotherapists

Our sport physiotherapists provides consultation, evaluation, and interventions for sports-related injuries.

#### 3.1 Consultation

During an individualized consultation, professional judgments and recommendations are given to athletes, coaches, and other professional disciplines (e.g. strength & conditioning coaches, sports sciences colleagues etc.).

#### 3.2 Evaluation

- a. *Ultrasonography* investigates on soft tissue and joint morphology and gives impression on the pathology. The device also monitors the progress of recovery.
- b. *Dynamometry* evaluates the strength and endurance of the athletes.
- c. *Sportkat* evaluates static and dynamic balance and joint proprioception of the athletes.
- d. *Functional Squat System* evaluates dynamic joint sense and proprioception of the athletes.
- e. *Electro-myography* provides valuable information on muscle recruitment.
- f. *Sports Oriented Testing* illustrates the functional problems of the athletes. It also provides a better understanding of the athletes' level of performance.

#### 3.3 Treatments and Interventions

Depending on the type of injury, different varieties of therapies are used to help athletes recover quickly. There are five main types of therapies.



a. *Physical Manual Therapy*

- *Joint Manipulation* treats joints dysfunctions.
- *Specific soft-tissue mobilization and Passive stretching* both tackle tightness and tension problems.
- *Joint mobilization with active exercise* helps to correct joint movement in active manner.

b. *Electrotherapy*

- *Ultrasound Therapy* treats inflammation and alleviates pain.
- *Interferential Therapy* treats pain.
- *Traction Therapy* provides longitudinal-oriented mobilization to spinal joints.
- *Electrical Stimulation* facilitates and re-educates muscle contractions.
- *Magnetic Therapy* facilitates the repair of fractured bones.
- *Extracorporeal Shockwave Therapy* promotes tissue healing in chronic conditions (focal) and tissue tension release (radial).

c. *Therapeutic exercise programme and rehabilitation, injury prevention, and sports performance enhancement*

- *Strength and Endurance exercise* promotes basic muscle power and durability of muscle contractions.
- *Range of motion/flexibility exercise* promotes joint mobility and tissue extensibility.
- *Balance exercise* promotes joint proprioception and static and dynamic stability.
- *Functional exercise* promotes athlete's ability to return to his or her specific sports' actions.
- *Agility exercise* promotes athlete's ability to cut, pivot shift, and etc.
- *Plyometric exercise* promotes athlete's ability to jump and land with good eccentric muscle strength, while properly controlling lower limbs.

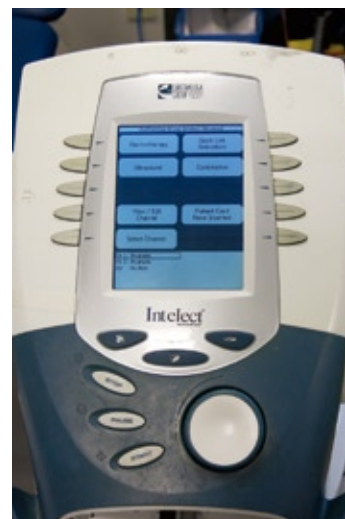


Figure 6.23 Machine for Interferential therapy and ultrasound therapy



Figure 6.24 Passive physiological rotation of L3/4 & L4/5



Figure 6.25 Self-mobilization for cervical spine



Figure 6.26 Stretching for hamstrings





Figure 6.27 Pulsed Electromagnetic Field Machine



Figure 6.28 Intervertebral traction machine

- **Cardiovascular training** increases the capacity of aerobic exercises.
- **Core stability and muscles control training** promote trunk and proximal body parts stabilizing and control abilities.
- **Clinical Pilates** helps in improving core stabilization, restoring normal movement pattern after injury and enhancing sport performance.
- **Rehabilitation Programme for post-surgical care**  
We provide specific rehabilitation programme for athletes with post-surgical condition. e.g. Anterior Cruciate Ligament (ACL) reconstruction, shoulder SLAP lesion repair.

d. **Acupuncture**

- **Western Approach Acupuncture** aims to reduce pain and muscle tension.

e. **Sports taping and Supportive device prescription**

- **Sports Taping** can be used to immobilize, facilitate, or support the musculoskeletal system. Depending on the athlete's condition, various wrapping methods can be applied.
- **Supportive Devices** including braces and straps could be prescribed by our therapists when necessary.
- **Casting for orthotics** Faulty or poor foot positioning can change the biomechanics of ones footwork, and may potentially lead to injuries. We assess and provide suitable orthotics as a preventative measure and may refer the athlete to specialist if needed.



Figure 6.33 Rigid & elastic taping



Figure 6.29 Strengthening exercise for shoulder



Figure 6.34 Tools and ointments for therapeutic use



*Figure 6.30 Balance and proprioception training for lower limb*



*Figure 6.31 Functional training for lower limb*



*Figure 6.32 Functional training for lower limb*

### 3.4 Some other duties of sport physiotherapist

#### *Clinical motion analysis*

Audio and vision equipment is used in our clinical motion analyses. We analyze the motion from a clinical perspective and give advices and interventions accordingly.

#### *Musculoskeletal screening examination*

Musculoskeletal screening examinations provide us with some of the basic information of our athletes' physical measurements. The screening is sport-specific and includes the evaluation of the athletes' joint range of motion, muscle strength, and many more. By identifying their physical limitation, a specific training programme can be recommended to their coaches for injury prevention and improvements in sports performance.

#### *Inter-communication with different discipline*

Athletes' injury reports are given to the head coach or coach-in-charge for their reference in training programme and inter-disciplinary communication.

#### *On-field service (local and overseas)*

Sport physiotherapist can provide professional on-field service upon request from head coach / coach-in-charge. Injury report will be given to the team head coach / coach-in-charge for their reference in training programme and inter-disciplinary communications.

## 6.C Massage and Recovery

Massage therapy has grown to become an integral part of the new athletic regime from the level of school athletics to Olympic training. At the highest level of performance, massage therapy may provide an extra edge to the athletes.

The nature of massage makes it an ideal complement to a total conditioning programme. The addition of massage to the conditioning programme allows the body to get into shape faster with less development of stiffness and soreness. It also helps the body to recover faster from heavy workouts and reduces the risk of injury. Western massage is currently the most common approach used for conditioning programme. The techniques are more focused on trigger point release, which can be more beneficial to the high performance athletes.

Muscle soreness and overuse injuries are common among high performance athletes. Overuse problems may develop in areas under greater stress or repetitive use during sports, and are mostly seen in sports of highly repetitive nature with an endurance component. One good example is cycling in which the athlete needs to perform thousands of virtually identical pedal strokes for up to a few hours a day, and more than a week in some events. At the other end of the spectrum is dance such as ballet, which entails a wide variety of movements, involves also considerable repetition within a performance as well as in rehearsal. These repeated movements involve many muscles working harmoniously in designated patterns and sequence to create the power and control needed for the specific sport movement. As each muscle has a unique function within a system, certain individual muscles may contribute to a greater extent within a movement pattern.

Some of the advantages of regular sports massage for elite athletes are:

- Reduce the chance of injury, through the loosening of connective tissues and muscles.
- Improve the range of motion and muscle flexibility.
- Shorten recovery time between workouts.
- Increase the supply of nutrient and oxygen through improved circulation.
- Enhance the elimination of toxic by-products of exercise.



*Figure 6.35 Hacking*



*Figure 6.36 Compression - Double hands for tender area*



Figure 6.37 Kneading (without oil)



Figure 6.38 Another kind of compression - using elbow for quadratus lumborum

Sports Massage is a type of technical massage specially catered to athletes and sports enthusiasts mainly to control soft tissues which include the skins, muscles, tendons, ligaments and muscle membranes. This type of massage can also be claimed to target at the imbalanced development of muscle membrane, sports trauma and harsh exercise regimes.

Originated in Asia, over 3000 years ago, this technique had been seen in China, India and Greece. Until 1776 to 1839, it was slowly spread to the western countries. The founder of the Swedish Massage – Per Henrik Ling, developed a new theory and technique of massage through treating injured athletes and gymnasts, slowly allowing sports massage to be accepted by world-class athletes, then became internationally recognized. At present, sports massage deserves a place in sports teams of various countries, including USA, Canada and Australia.

## SERVICE PROVISION

### 1 Sports massage techniques to suit different situations

#### *Pre-exercise*

Exercise is generally divided into “Training Phase” and “Competition Phase”. The type of massage given to the athletes before these two phases is called “Pre-exercise Sports Massage”. This type of massage able to stimulate the athlete’s nerves, muscles, circulation for the joints, as well as the body and the mental state. This treatment is very valuable to help the athletes to prepare for any form of exercise.

#### *Pre-training*

This type of massage is usually used to help athletes to increase their efficiency for the training. This type of massage focus to aid their physical development and to prepare their body for competition. The type of event, and the athlete’s own physical condition have to be taken into account.



Figure 6.39 Pre-exercise massage for shoulder



*Pre-event*

Pre-event Sports Massage is very common in western countries and it often lasts 15 to 20 minutes per session. Focusing on preparing an athlete for competition, it helps to stimulate the blood circulation of the athletes. On the side of muscle toning effect, pre-event massage can help to warm-up the major muscles and calming the muscle tension, thus the tissues flexibility could be improved. As a result, it allows the athlete to reach its maximum potential.

*Intra-event*

Intra-event Sports Massage is given to athletes between events or on the day of the event to help them recover their physical status. The time needed for this type of massage is relatively short and the idea is to focus on muscles that may have been stressed during the event.

*Post-event / Rehabilitation*

After a session of intense training or competition, the nervous system, circulation, pulmonary system, metabolism and the lactic acid balance of the athletes may go through numerous changes. Those changes might result in muscle and tissue imbalance within the body. Under this sort of situation, it is important to reduce or eliminate these problems by speeding up the recovery process, in order to enhance and increase the athletes' capacity for the coming up competition in the nearest day.



*Figure 6.40 Post-exercise massage to facilitate recovery*

*Recovery*

A full body massage of around 90 minutes is often done once a week. This session is relaxing but not the same as those relaxation treatments in the spas. The best recovery massage should be done after a warm or hot bath. Such massage employs techniques that move along the blood circulation and lymphatic drainage systems, which aims to aid in recovery and reduce any stress and discomfort after sports activities.

## **2 Sport Massage Therapist**

The effect of sports massage quite rely on therapist's clinical knowledge on human anatomy as well as their experiences. The understanding of sports biomechanics is very important too. If the therapist is an exercise fanatic and has regular sports training, it must be an added bonus.

### 3 Sports Recovery Centre

#### *Facilities*

Sauna Room, Jacuzzi, Massage Chair, Cold Plunge.

#### *Opening Hours*

Please refer to the time table posted in the waiting area of our Centre.

#### *Contraindications*

Cardiac problem; Pregnancy; Circulatory problem; Fever/Flu; Diabetes Feeling sick; Open wound; Skin disease; During a period; Athletic feet; Haemorrhoid; Venereal Disease.



Figure 6.41 Sauna Room



Figure 6.42 Jacuzzi



Figure 6.43 Massage chair



Figure 6.44 Cold plunge



## 6.D Chinese Medicine Service

As one of the medical professionals in the Centre, our Chinese Medicine Practitioner (CMP) works together with other disciplines to provide Chinese medicine consultation and treatment protocol for athletes.

### 1 Consultation

Athletes can come to CMP for treatment when they need, recommendations will be given either for herbal medications or physical treatments.

#### *Acupuncture*

For injured athletes, acupuncture is used for relief. Their body will respond to the needles by further increasing the flow of oxygenated blood to the injured area, which helps speed up the healing process.



*Figure 6.45 Acupuncture*



*Figure 6.46 Cupping*

#### *Cupping*

In cupping the resultant low pressure in the cup-to-body space causes a localized expansion of the tissue. This then causes a profound vasodilatation reaction. Thus, cupping is used to increase blood flow to painful constricted areas, and to re-supply vital nutrients and oxygen.

#### *Gua sha*

Gua sha is a technique involving scraping the skin covered with oil, using a smooth-sided object. The side of a typical Chinese porcelain spoon or other small and smooth object is used. The oil contains herbs that, along with the scraping action, enhance vascular dilation. This technique is used to remove stagnation and improve circulation in the superficial region. It produces a reddening of the skin which can last a full day.



*Figure 6.47 Gua sha*

### Moxibustion

It is part of acupuncture therapy and is used to treat musculoskeletal disorders (bruises, sprains, tendonitis); it has anti-inflammatory actions for arthritis as well as immune modulating effects for lupus and airborne allergies.

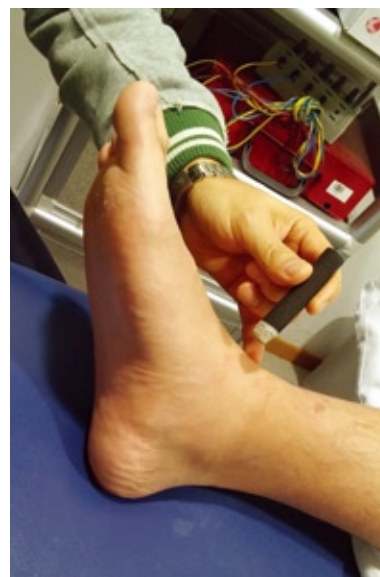


Figure 6.48 Moxibustion



Figure 6.49 Herbal medications

### Herbal Medication

Several elite athlete's custom-made herbal medications provided from Sichuan Orthopaedic Hospital had been introduced to the Centre since 2015, they can help increase blood flow and treats inflammation.

## 2 Chinese Medicine Specialist's Referral

### Co-operation with Hong Kong Baptist University Chinese Medicine Clinic

- Athletes with health problem who come to CMP for advice, if herbal treatment is needed, they will be referred to the Clinic.
- In order to monitor the rehabilitation progress of the injured athletes, their medical records are shared between two parties.
- In some complication cases, CMPs in both parties will share opinion, experience and treatment modalities.
- CMPs in the Clinic will be reminded and updated frequently for the anti-doping policy.

## 6.E Chinese Manual Therapy

The HKSI aims to set a centralised, integrated biopsychosocial support systems targeting all aspects of medical and physiological, psychological and social support needs for elite athletes. Chinese medicine plays an important role in achieving China's remarkable sporting success. Benefitted from the good relationships between the HKSI and China Sports Medicine Association, we could introduce both their human resources and experiences to HKSI. At present in the Sports Medicine Centre, we have a seven-person Chinese manual therapist team as part of our multi-disciplinary support system.

The Chinese manual therapist team are composed of highly qualified and experienced individuals, with diplomas from medical schools (Chinese or Western medicine), rehabilitation and other professional qualifications in Mainland China, and have worked as medical staff for the national team or provincial teams. Under the guidance of the medical consultants at the HKSI, these manual therapists provide treatment, rehabilitation service and team support. With the reasonable configuration of professionals, Chinese manual therapists can offer more comprehensive support to athletes in terms of sports injury treatment, rehabilitation, fatigue recovery as well as on-field support. They are playing an active role in the diversified and integrated service system at HKSI, as well as going to the Olympic Games, Asian Games and All China Games along with athletes as part of the Hong Kong delegation.

### 1 Basic elements of manual therapy

Different schools, styles, techniques and procedures of manual therapy have been developed worldwide. In China, over 460 kinds of manual techniques from different schools are recorded in "The Complete Guide of Manual Therapy in China". There is now a general consensus that force, frequency and the direction of the applied force are the three basic elements of manual therapy regardless of which technique is adapted. Manual therapy essentially involves the manipulation of different combinations of these three basic elements.

#### *Force*

Force is the amount of pressure applied to the patient's body part(s) by the therapist includes both absolute force and force per unit area (i.e. intensity of pressure). The latter is more significant in determining the intensity of the force. Thus, the size of the area of the force applied on the body determines the intensity of pressure. Being the foremost essential element of the manual therapy, appropriate force is the key to successful treatment. Intensity of the force applied varies among different individuals, conditions and according to the specific nature of the injured tissue. Gentle force must be applied when working with the elderly, children, patients with acute injury or unknown diagnosis. On the contrary, strong stimulation can be applied to patients with strong physique, chronic conditions and a clear diagnosis. Force can be applied on a larger area for large muscle or on a smaller area with great pressure for tendons, ligaments and the periosteum (the thick fibrous membrane of connective tissue covering the entire surface of bone except for its articular cartilage, which serves as an attachment for muscle and tendons).

### *Frequency*

Frequency refers to the time required to complete a single movement, or the number of movements that completed per minute. In traditional Chinese medicine, manual therapy can produce tonifying and purging effects on the meridian system. Generally speaking, tonifying techniques refer to low frequency, long duration, light force applied along the route of meridians, which stimulates and strengthens the human body. On the contrary, high frequency, short duration, high force stimulation applied in the opposite direction to the meridians is known as purging technique, which restrains and tranquilises the body. In the modern study of physiology, high frequency and short duration stimulation induces excitement while low frequency and long duration stimulation induces suppression. In regular treatments, the therapist must pay special attention to identify different conditions and injured body parts, and differentiate acute from chronic conditions. In fostering athletes' health, we must adopt different approaches to cater for their different needs in various situations like training, pre- and post-competitions, high intensity training, recovery, training adaptation periods, etc.

### *Direction of force*

This refers to the direction of force applied on the patient's body or the direction of movement applied against the body, tissues and organs. Using the same amount of force but towards different directions produce different effects. For example, vertical pressure relaxes the body while horizontal scraping reduces inflammation. In addition, different directions of movements against the body or tissues induce completely different effects. Pushing along the axis of the body or tissues produces an optimum relaxation effect. Plucking and yanking across the axis of the body or tissues stimulates the body which is effective for serious chronic injury.

According to Chinese medicine theory and philosophy, the combination of varied force, frequency and direction of force produces different effects on the body. All these elements are crucial in determining the effectiveness of the treatment. In conclusion, it is extremely important to choose the appropriate manual therapy technique to deal with patients of different ages and gender. The technique chosen will also depend on the specific tissue, body parts and the nature and level of the injury.

## **2 Chinese manual therapy for athletes**

Athletes participating in competitive events often push their bodies to the human limit during the course of training and competition. Those participating in contact sports and events using equipment have an even higher risk of accidents. Therefore, the likelihood and severity of injuries among athletes may be much higher than among common ordinary people. Besides the therapists are facing numerous restrictions and limitations as they have to adjust their treatment with regard to coaches' plan amid training and competitions, thus posing demand for higher standard of manual therapy. Based on our years of experience in treating elite athletes, we summarise briefly in this article a set of effective methods of sports manual therapy.

## 3 Basic techniques of sports manual therapy

### 3.1 Manual diagnostic techniques: Palpation

The therapist touches the injured and surrounding area carefully with his/her fingertip, finger pad, the whole finger (mostly thumb), pisiform (the small round bone on the outer edge of the wrist), the whole palm, elbow, foot and heel. Force is applied from the surface deep into the skin, from gentle to strong, which enables the therapist to identify the real signs of injury and to judge the level and nature of injury. Then, appropriate treatment techniques are chosen. The therapist seeks to evaluate the following elements using palpation:

- In skin and subcutaneous tissue: temperature, flexibility (tension), disrepair, swelling and tumors.
- In muscles (tendons) and ligaments: temperature, flexibility (tension), spasm, atrophy, swelling from partial tear, separation from complete tear, cord-like tissue, nodules, pain, noisy joint and dislocation.
- In bones and joints: temperature, range of motion (hypomobile, hypermobile, accessory movement), swelling (bleeding, effusion), fracture, subluxation and dislocation.

#### *Functions of palpation*

- Determines the depth, size and nature of the injury. In combination with other tests to determine the location of the injury, whether it's on the skin, muscles, tendons, ligaments, joint space, periosteum, fracture, subluxation and dislocation, etc.
- Choose the appropriate treatment methods based on the diagnosis. Press with finger on patients with acute injury. Kneading, pinching, pushing and pressing can be applied on muscles while other techniques like pinching; fingertip pressing and scraping can be applied on tendons and ligaments.
- Evaluate the treatment response and adjust it accordingly.

### 3.2 Fixed-point manual techniques

Pressure is applied on a relatively fixed-point of the skin and there is no movement between the contact areas. Examples are kneading, pressing, fingertip pressing and pinching.

- ***Kneading:*** Rhythmic circular movement (using therapist's thumb, pisiform and the whole palm, etc.) is suitable for skin, subcutaneous tissue and muscles.
- ***Pressing:*** Repetitive vertical force (using therapist's thumb, pisiform, fist, elbow, knee and foot etc.) is applied on deep muscles, ligaments and tendons.
- ***Fingertip pressing:*** Repeated pointing stimulations (usually using fingertip) applied on one or two points of the injured body part is suitable for tendons, ligaments, bones, periosteum and the insertion point of the tendon in particular.
- ***Pinching:*** Rhythmic alternate pinching (using therapist's thumb and index finger, thumb and the other four fingers as well as left and right palms) on two points is suitable for subcutaneous tissue, muscles and tendons.

### *Functions of fixed-point manual techniques*

- Enhance the flexibility and tensile strength of muscles and ligaments.
- Reduce bruising; decrease spasm (including blood stasis, induration (hardening) of muscles, tendons and ligaments).
- Relieve fatigue; eliminate muscle soreness and weakness.
- Restore joint dislocation and align fractured bones.

### *Notes to fixed-point manual techniques*

- Make good contact with the skin and do not slide over it, excess friction will cause skin breakdown.
- Force should be firm but gentle, abrupt or strong force may cause body injury.
- Should not be applied on acute injuries with bleeding or highly swollen tissues as it may cause bleeding and aggregate the swelling.
- Kneading and fingertip pressing on a position for too long leads to swelling and bleeding easily.
- Force should be applied evenly.

## 3.3 Moving-point manual techniques

- Massage methods, such as pushing, scraping, plucking and yanking, where force is applied onto a certain area of the body towards a specific direction are known as moving-point manual techniques.
- **Pushing:** Rhythmic pushing towards the direction required (using therapist's thumb, pisiform, fist, palm, elbow or foot, etc.) which is suitable for injured body parts like subcutaneous tissue, muscle, ligaments and tendons.
- **Scraping:** Rhythmically scrape the injured area in a specific direction (usually along body hair orientation, by using thumb-nail, fingertip, coin or other scraping tools). This is suitable for injured body parts like skin, subcutaneous tissue, tendons, ligaments, bones, periosteum and the insertion point of the tendon.
- **Plucking:** Plucking can be used for deep muscle, ligament and tendon. The treating muscle and tendon are being picked, pulled and plucked quickly, and the released to spring back to original position, which resembles the action of plucking string on an instrument.
- **Yanking:** Yanking is suitable for body parts like muscle, ligaments and tendon adhesion and scars. Apply pressure (with thumb or olecranon of elbow) to reach the required tissue level, and rub it back and forth (usually transverse to the soft tissue fibers) in order to break the adhesion and thickening.



### *Functions of moving-point manual techniques*

- Break down the nodules, fibrotic and calcified tissue along the muscle and tendon. Softens adhesion and scarring.
- Eliminate localised fatigue (apply force towards the heart), and relieve soreness and pain.
- Localised stimulation relieves numbness and paraesthesia (abnormal skin sensations with peripheral nerve damage).
- Pushing has positive effect on realignment of joints; it can also help in closed reduction of fractures.
- Whole body pushing (the application of force away from the heart) has a cooling down and calming effect.

### *Notes to moving-point manual techniques*

- The choice of manual techniques is based on the patient's physique and general health, the nature and severity of injury, the size of the injured area and how well the patient responds to the technique applied. Gradually increase the force applied to ensure no adverse reaction.
- Avoid friction between the operating hand and patient's skin during the course of massage to prevent skin breakdown.
- Avoid hurting the patient with fingernails and tools.

## **3.4 Auxiliary manual techniques**

Shaking, tapping and pulling techniques play a supporting role in manual therapy. Pre-treatment pulling increases the elasticity of soft tissue and range of motion of joints. Auxiliary techniques like shaking and tapping have a warming up effect to help relax the tissues, joints and the whole body.

## **4 Diagnosis using manual therapy techniques**

Sports manual therapy is developed from the combination of naprapathy (the branch of manual medicine that focuses on the evaluation and treatment of neuromusculoskeletal conditions) of Chinese medicine and the strengths of non-invasive therapy of Western medicine. Diagnostic imaging (such as X-ray, CT scan and MRI, radiological and ultrasound imaging, etc.), laboratory tests, functional evaluation and biomechanical analyses, etc. are the major state-of-the-art medical technologies applied in sports injury diagnosis. However, manual therapists rely on the information felt through their hands and on observation for diagnosis when diagnostic imaging is not available. Effective treatment depends on accurate diagnosis, thus palpation plays a significant role in manual therapy. Muscles, tendons, ligament fascia, nerves and even joints have a certain degree of tension and evenness or smoothness. Based on extensive experience with successful elite athletes, a therapist can expect that soft tissues under palpation will be perceived as follows:

## 4.1 Palpable signs of normal soft tissue

- **Muscles:** Plump and resilient, robust and soft, with smooth, even texture with a clear border.
- **Tendons:** Tenacious and strong, fine and even with apparent border.
- **Ligament fascia:** Compact and firm, smooth and thin. It is better not to touch ligament fascia.
- **Joints:** Well shaped appearance, not swollen, full range of motion.

## 4.2 Palpable signs of fatigued soft tissue

- **Muscles:** Increased muscle tension, decreased muscle elasticity and apparent signs of dull pain. Decreased muscled tension without pain on palpation is a common sign of chronic fatigue. However the therapist needs to carefully assess and differentiate peripheral nerve injury from chronic fatigue.
- **Tendons:** Thickened tendons, damaged uniformity, olive-shaped, adhesion of fascia and ligaments, and apparent feeling of pain and tenderness are common signs after the stage of muscle fatigue.
- **Ligament fascia:** Thickened and puffy, apparent laxity presented, touchable and tender on palpation.
- **Joints:** Deformed, swelling, decreased range of motion.

## 4.3 Palpable sign of the injured soft tissue

- **Muscles:** For partial muscle tears: intact muscle involucreum, increased tension, decreased elasticity, excruciating pain. For complete muscle tears: damaged muscle involucreum, swollen peripheral tissue and obvious depression at rupture site, pain. For chronic injury or unrecovered injury: palpable hard nodule, cord-like tissue and scarring, with tenderness.
- **Tendons and ligaments:** for chronic injury or unrecovered injury: palpable nodule, cord-like lump and rough scarring.
- **Joints:** Torn and worn soft tissue and cartilage is a common cause of sports injury, which affects athletes to a large extent. As a matter of fact, many athletes retire because of this reason. Therefore, early diagnosis and treatment is extremely important. Manual assessment of joint flexibility can detect and locate minor injury and subluxation of joint, so as to evaluate the treatment effectiveness. It is much more meaningful than only examining the range of motion.
  - Joint shocking test: When the athlete is completely relaxed, move the joint passively and quickly in all physiological directions to available range. Pay attention to the smoothness of the movements, and where the resistance is and at what range the pain appears. It is commonly used in assessing knee and hip joints.
  - Joint swinging test: when the athlete is completely relaxed, gently pull and swing the joint passively to find where the resistance is and at what range the pain appears. It is commonly applied on shoulder and elbow joints.

## 4.4 Palpable sign of the fractured bone

The soft tissue will be swollen and a pressing pain will be resulted around the fracture site. It is also very tender on palpation. For a minor fracture (crack fracture), there is no displacement and obvious deformities can be observed or palpated. For fractures with displacement or comminuted fractures ( in which separated parts are splintered or fragmented), there are visual deformities and the fracture site can be located by palpation. A sense of friction and noisy bone rubbing can be heart when moving the involved limbs. For fractures associated with vascular injury, weakening pulse on the touchable injured body parts and abnormal pulse will be detected.

## 4.5 Palpable sign of the dislocated joint

It is easy to diagnose big joint dislocation and apparent small joint dislocation by observing the dislocated deformity. For subluxation, there will be localised swelling and it is painful on palpation. The feeling during manual restoration and the decrease in symptoms after restoration justify the effectiveness of the treatment.

# 5 Applications and precautions of sports manual therapy

Sports manual therapy is applicable to all acute and chronic injuries, so as to relieve fatigue and to restore physical strength. In order to make the best diagnosis of injury, it is important to understand the characteristics of different sports. Based on the specific injury mechanism, injury site, involved tissue, intensity of injury, and with the confirmation of modern medical technologies (X-ray, ultrasound imaging or MRI, etc.), the therapist confirms diagnosis and applies the most appropriate manual therapy for the patient. Different treatments for patients of different age, gender, physique and level of injury should be chosen carefully. It is also particularly important to take training programmes and competition schedules into account. For serious joint injuries, muscle, tendon and ligament ruptures, special attention should be paid in applying manual therapy and focus should be placed in conjunction with surgical treatment. For patients with infection, bone loss (such as bone tuberculosis and tumor), acute unknown traumatic diagnosis, unconsciousness or mental illness, application of manual therapy is contraindicated.

## 5.1 Chinese manual therapist service procedures

- Athletes requiring sports injury treatment need to first consult a HKSI consulting doctor. After a diagnosis, they should follow the doctor's suggested treatment method. For athletes suffering from chronic injuries, therapists should arrange for follow up consultation with the consulting doctor after their scheduled treatment.
- Athletes who are fatigued and require manual therapy to relieve fatigue should make an appointment themselves, the therapist make the arrangement for the relaxation therapy and report the athlete's situation to the coaches.

- When a therapist is needed for on-field support service, elite sports coaches should seek approval from the Elite Training Science & Technology Director. During the on-field period, therapists should report to the coaches, accommodating the athlete's training and competition schedules when planning an athlete's treatment and resting agenda.
- Chinese manual therapists' services are only obligated to a doctor's prescription treatment and relaxation therapy. They are not in the position to certify an athlete's injury or illness, nor can they make the decision for an athlete to stop training or any other decisions contradictory to the coach's training plan.

## 5.2 Precautions of Chinese manual therapy

- During the treatment of Chinese manual therapy, pain or even intense pain may occur. Therapists have the responsibility to explain and minimise the pain, while athletes should communicate with the therapist according to his/her tolerance level to receive the appropriate treatment.
- When treating chronic injuries, Chinese manual therapy operates on the principle of first stimulate the injured area then undergo recovery healing. Besides pain during treatment, there is also short-term affect on the functioning of the area. Under certain circumstances, swelling and blood congestion may occur. Therapists should be clear of the athlete's training and competition cycles and adopt a reasonable course of treatment. Athletes should reflect on the effect of the treatment in a timely matter and promptly adjust his/her training. For the best results, both parties must act together.
- Athletes with fever, inflammation is not suitable for manual therapy, female athletes should also avoid intense stimulation during their menstrual cycles. Serious acute injury without a clear diagnosis should not be subject to manual therapy.
- Manual therapy is often conducted in collaboration with physical therapy, speeding up the recovery with the combined therapy, to get the athlete back to training and competition standard as soon as possible. In manual therapy, a combination of ice, foment, externally applied agent and taping. Acupuncture is also used in combination if necessary to improve effect of treatment.

## **MODE OF CO-OPERATION BETWEEN DIFFERENT DISCIPLINES**

Under the elite training system, an injured athlete goes through a well-structured, effective and timely rehabilitation programme in order to alleviate the adverse impact of injuries on training and/or competition. In order to achieve this, a comprehensive integration of East and West approaches in the practices of sports medicine as well as a multi-disciplinary approach are employed in the Centre. The different professionals in the Centre and in HKSI work in a coordinated manner to handle the injury cases.

For a complicated or urgent case, a case management team will be formed and led by an Honorary Medical Doctor. The members include but not limited to the injured athlete (the patient)'s direct coach, conditioning coach, sport psychologist, sport nutritionist, sport physiotherapist, Chinese manual therapist etc. The case management team based on the professional advice from each party will develop a rehabilitation programme for the patient. Frequent meetings will be carried out to monitor the progress of recovery until the rehabilitation is completed.

## EQUIPMENT INVENTORY

| Equipment  | Brand & Model                  | Quantity | Purpose of use  |
|--|--------------------------------|----------|---|
| Anti-gravity treadmill   | Alter G                        | 1        | Gait education with unweighting technology  |
| Ultrasound & electrotherapy combined machine                                   | Chattanooga                    | 2        | Ultrasound therapy & electrotherapy for inflammation, pain, muscle spasm & muscle atrophy                         |
| Portable ultrasound & electrotherapy combined machine                          | Chattanooga                    | 3        | Ultrasound therapy & electrotherapy for inflammation, pain, muscle spasm & muscle atrophy during overseas support |
| Radial shockwave therapy machine   | STROZ MEDICAL MasterPuls MP200 | 1        | Shockwave therapy for chronic inflammation, scar adhesion, muscle spasm   |
| Focal shockwave therapy machine  | Sanuwave EvoTron               | 1        | Shockwave therapy for chronic inflammation & scar adhesion  |
| Diagnostic ultrasound machine  | Toshiba                        | 1        | Examination of soft tissue injuries using diagnostic ultrasound imaging technique                                 |
| Portable diagnostic ultrasound machine<br>ultrasound                           | Esaote                         | 1        | Examination of soft tissue injuries using diagnostic ultrasound imaging technique during overseas support         |
| Traction machine with treatment plinth   | Triton                         | 1        | Traction therapy for neck and lower back problem  |
| Pulse magnetic field system  | Magnetopulse International     | 1        | Magnetic field therapy for swelling, soft tissues injuries and fracture   |
| Machines, dynamometer & software for isokinetic assessment/<br>training system | Humac Norm CSMi                | 1        | Isokinetic assessment for extremities & trunk with reports generated, can also be used for isokinetic training.   |
| Treadmill with adjustable gradients  | Precor C964i                   | 1        | Gait education & cardiovascular training  |
| Cable system for functional training   | Technogym Kinesis              | 1        | Functional training of more advanced or specific movement patterns  |



## SPORTS MEDICINE CENTRE

| Equipment   | Brand & Model   | Quantity | Purpose of use  |
|---|---|----------|---|
| Pilates equipment:                                | Balanced Body   |          | Core stability training and exercise for mobility and good posture.   |
| - Clinical reformer                               |   | 1        |   |
| - Trapeze table                                   |   | 1        |   |
| - Ladder Barrel                                   |   | 1        |   |
| - Combo chair                                     |   | 1        |   |
| Whole body vibration machine (vertical vibration) | Fitvibexcel   | 1        | Vibration platform creating vertical vibration in different frequency and amplitude for facilitation of muscle activation or muscle relaxation        |
| Whole body vibration machine (see-saw vibration)  | Physiowave 700  | 1        | Vibration platform creating see-saw type of vibration in different frequency and amplitude for facilitation of muscle activation or muscle relaxation |
| HyperOxygen Unit                                  | OxyHealth Vitaeris 320 portable Soft Hyperbaric Chamber Set | 2        | For athletes recovery   |
| Hydrotherapy facilities                           | SausPa (1 set), Jacuzzi (1 set)                             | 2        | For athletes recovery   |
| Sauna facilities                                  | SausPa (1 set), TYLO (1 set)                                | 2        | For athletes recovery   |

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# CHAPTER 7

## SPORTS INFORMATION CENTRE

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### Introduction

The Sports Information Centre provides sports information services to support the planning and implementation of elite training programmes and initiatives and research needs. It serves sports science and sports medicine professionals, coaches, athletes, NSAs, academic institutions, physical education specialists, and communities. The Centre also plays a key role in the coordination and management of a broad range of international cooperation activities, collaboration programmes and special projects within the Elite Training Science & Technology Division including visits and exchanges, cooperation programmes, the HKSI's annual International Sports Science Symposium as well as providing administrative and technical support for the Division's scientific research and publications.

## 7.A Research and Analysis on High Performance Sports Information

The Centre conducts detailed research on all aspects of the elite sports supported by the HKSI.

### SERVICE PROVISION

One key area of work is to collect, manage and analyse sports data and information. The sports data and information includes results and records for competitions and major multi-sports games, rankings, rules and regulations, news and scientific articles. The sports data and information is disseminated to coaches and sports science and medicine team for training, research, management and decision making purposes.

With the support of athletes, coaches and NSAs, the Centre conducts research projects and evaluation surveys on elite training programme and multi-sports games support. The results help coaches and administrators to monitor the effectiveness of the range of support given to athletes. The Centre also reviews the overall performance of Hong Kong athletes and competitors after each multi-sport game for strategic planning purpose.

## 7.B Resource Centre

The Sports Information Centre manages a resource centre which is located on the second level of the HKSI Main Building. The facility was first opened in October 1991 and named as Hong Kong Sports Information Centre. The centre moved to the current location in September 2013 and renamed as Sports Information Centre, it boasts a spacious environment to cater for users' training and research needs.

### SERVICE PROVISION

The resource centre is a specialised resource centre of sport and exercise sciences, it serves as a convenient one-stop, centralised information hub for anyone practicing in the field of sports, including coaches, athletes, sports administrators, policy makers, researchers, physical activity educators, sports scientists and medical staff, and many others.

The resource centre houses books and serials (mainly compose of journals, magazines and newspapers), reference materials, audio-visual materials, electronic databases and publications published by the HKSI, a rich collection of historical images on Hong Kong sports, and a Hong Kong local sports channel. To help users fully benefit from this breadth of information, the resource centre provides reference services, interlibrary loan services and photocopying service, reading areas and a group discussion room, networked PCs for accessing library services, collections and library-subscribed electronic resources and navigating the Internet. Free Wi-Fi service is provided for patrons.



Figure 7.1 Shelves of printed materials



Figure 7.2 Reading area



Figure 7.3 Computer workstations and multimedia services workstations



The resource centre serves current staff, coaches and athletes of the HKSI and members of the public in Hong Kong. Non-members are welcome to visit the resource centre during the opening hours. Details on membership categories, fees and privileges, and opening hours are available from the HKSI's website.

## EQUIPMENT INVENTORY

| Facilities  | Quantity | Purpose of use   |
|---|----------|--|
| Reading area<br>- Newspapers racks<br>- Magazines racks<br>- Periodicals cabinets<br>- New title display racks<br>- Tables and chairs   | -        | Newspapers, magazines and other periodicals can be found in the reading area. The materials are for use in the resource centre only. |
| TV area   | -        | Sports TV channel provides local and international sports news and competitions for viewing by patrons.                              |
| Computer workstations<br>Operating systems include:<br>- Chinese Windows 7<br>- English Windows 7   | 6        | For patrons to access library services, collections and electronic resources and navigate the Internet.                              |
| Multimedia services workstations (Media resources workstations)<br>Available equipment includes:<br>- TVs<br>- CD/DVD Players<br>- VCR<br>- Audio cassette deck<br>- Headphones | 1-2      | For patrons to access resource centre's media resources.   |
| Photocopier with Octopus reader   | 1        | Self-service photocopying service of A4 and A3 sizes on a charging basis.  |
| Wi-Fi Service   | -        | Free wireless Internet access service available for patrons.   |

## 7.C International Relations

The HKSI maintains frequent exchanges with sports professionals in mainland China and overseas in order to stay at the forefront of global trends in elite sports development.

### SERVICE PROVISION

#### 1 Memorandum of understandings (MOUs)

International exchanges with the HKSI's counterparts are an integral component of providing quality elite training for Hong Kong athletes. The HKSI signed MOUs with sports organisations in mainland China and other Asian and European countries to collaborate in areas including training, sports science and medical support, research, and major sports event preparation.

The signing of a MOU between the four founding members of the Association of Sports Institutes in Asia (ASIA) – the HKSI, Aspire Academy (Qatar), Japan Sport Council (JSC) and Singapore Sports Council was conducted on 25 February 2015, marking an important milestone in closer ties between the HKSI and other institutes in the Asian region and providing a platform for cooperation in the areas of high performance. ASIA is the region's first association bringing together Asian high performance training centres. It is a non-profit and non-government organisation with a mission to foster the best practices of long-term Asian athlete development through a comprehensive model of collaboration, exchange of expertise and networking opportunities for athletes, coaches, sports scientists, and administrators of high performance sports in Asia.



*Figure 7.4 Preparatory Executive Committee of ASIA, senior management of the JSC at MOU signing ceremony on the establishment of ASIA on 25 February 2015*



*Figure 7.5 The HKSI signed a MOU with the Huize Altitude Training Base under the Culture, Sports and Broadcast Bureau of Huize County (Bureau) on 11 May 2015 in Yunnan, aiming to provide an excellent natural environment for Hong Kong athletes to undergo hypoxic training to improve their sporting performance*

## 2 Symposia and seminars

### 2.1 HKSI International Sports Science Symposium

Aiming to promote local and international exchange to keep abreast of the latest developments in elite training, the HKSI regularly organises the International Sports Science Symposium with different themes.

The two-day symposium is a yearly meeting of academics, scientists, coaches, athletes and administrators in the field of elite sports. The HKSI invites renowned experts and collaborative partners to share latest knowledge and application, innovations and discoveries in sport science and technology through lectures, workshops, demonstrations, panel discussions, and poster presentations. In addition to providing a valuable occasion for ideas and perspectives to be shared and learned, each meeting brings potential collaboration opportunities as professional and sport business counterparts meet and share. The symposium adopts themes on various sports science disciplines and Games preparation. The HKSI co-organises the symposium with various international and local sports organisations and universities, which helps the HKSI maintain a close working relationships with them. Each meeting attracts on average 200 - 300 overseas, mainland China and local participants.



*Figure 7.6  
HKSI senior management, representatives of the co-organisers, and guests at the opening ceremony of the HKSI International Sports Science Symposium on 16-17 January 2015*



*Figure 7.7  
HKSI senior management and HKSAR government representatives, and guests at the opening ceremony of the International Exchange Forum on Preparing Athletes for 2016 Rio Olympics on 20 December 2015*

## 2.2 Other scientific forums and seminars

The HKSI organises other scientific seminars each year such as the Elite Training Seminar Series. The Seminar Series provides an interactive platform for sharing information and experience among all local stakeholders involved in elite training. It aims to facilitate mutual understanding and effective cooperation among support service professionals in elite sport, with the ultimate goal of maximising state-of-the-art, multi-disciplinary support for Hong Kong athletes to achieve excellence in sport. Speakers are invited to present on a predetermined topic, and facilitate discussion among participants. The topics are practical and designed to improve scientific services provided for elite training.

In addition to the Seminar Series, the HKSI organises other conferences, seminars and workshops jointly with the HKSI's counterparts on various scientific areas including strength and conditioning, talent identification, elite training programmes and technologies. Two of the most important conferences jointly organised with our counterparts were the Asian Conference on Sport Science (ACSS) in October 2013 and the first annual congress of the Association of Sports Institutes in Asia (ASIA) in March 2016.

The ACSS is organised every two years, alternately by the China Institute of Sport Science (CISS), Japan Institute of Sports Sciences (JISS), and Korea Institute of Sport Science (KISS), to enhance academic exchange and provide networking opportunities within the Asian sport societies. The 2013 conference was hosted by the HKSI and was held on 25 – 26 October 2013. Experts and professionals from mainland China, Japan, Korea, Singapore, Malaysia, Qatar, Germany, Netherlands, Australia, Canada and Hong Kong came together to present and speak at the Conference. The conference theme was *Sport science and elite training programme for world class performance*. The presentation topics focused on current trends and innovations in practice in different areas of specialisation, namely scientific support in elite training, conditioning, sport information and sport-for-all.

The Association of Sports Institutes in Asia (ASIA) was established in February 2015 and is the region's first association bringing together Asian high performance training centers. ASIA's mission is to foster the best practices in the area of long-term Asian athlete development through a comprehensive model of collaboration, exchange of expertise and networking opportunities for administrators of high performance across all of Asia. The annual congress gathers Asia's most influential performance practitioners to share insights and spark discussion that will help shape the future of sport in Asia. The inaugural annual congress was held on 15 – 16 March 2016. It attracted representatives from Malaysia, Philippines, Saudi Arabia, Singapore, Taiwan, and Papua New Guinea. The presentation topics focused on current trends and innovations in practice in different areas of specialisation, namely leadership and management, pathways to innovation, and branding and marketing of high performance institutes.





*Figure 7.8 HKSI senior management and the HKSAR government officials, and representatives of the co-organisers at the opening ceremony of the Asian Conference on Sports Science on 25-26 October 2013*



*Figure 7.9 Preparatory Executive Committee of ASIA, the senior management of the JSC, and speakers at closing ceremony of the Inaugural Congress 2016 of the ASIA on 15-16 March 2016 in Tokyo, Japan*

### 3 Visits and exchange

The HKSI often receives local and international visitors, mainly from sports, professional and education institutions, as well as community and corporate organisations, to promote mutual exchange in the field of sports. The visitors will be invited to join a tour of the training and sports science and medicine facilities and meet with our coaches, scientific and medicine team, and management staff.

### 4 Research programmes

Applied research underpins the HKSI's work on elite training by building a credible evidence base in sports science, sports medicine and sports technology to improve the efficiency and effectiveness of training. Research has practical value and application in regard to preparing the athletes in that the outcomes of research provides knowledge and information for understanding the mechanism that lead to improved performance and developing training tactic. Research work helps Hong Kong take the lead on some training aspects, create and sustain competitive advantage over competitors.

The HKSI's in-house scientific and medicine team manages an annually-reviewed, applied research programme in which the research will have a practical application in preparing our athletes for international competitions. The team also looks at innovation in the areas of training science, equipment and coaching technologies that will have a direct performance outcome for athletes. Research covers biochemistry, biomechanics, performance nutrition, performance psychology, physiology, talent identification, medicine, physical therapy, strength and conditioning, performance analysis and skill

acquisition, and technology. To create synergy, the team collaborates with various higher education institutions, research institutes and commercial organisations both in Hong Kong and overseas on specific research. In addition to presenting research work and findings at academic conferences, the team publishes research work and findings in peer-reviewed journals, monographs, handbooks and *Research Highlights*. *Research Highlights* is a one-page summary which covers the background, methodology, findings and implication and conclusion for a research project. *Research Highlights* are available for viewing from the HKSI website.

In addition to providing administrative support to the research programme, the Centre conducts surveys to evaluate and monitor the needs of coaches, athletes and NSAs on various areas of support for our athletes.

## 5 Scientific publications

Publications provide a platform for exchange of knowledge and expertise and encourages scientific collaborations. The Centre provides administrative support to the HKSI's in-house scientific and medicine team in the publication of research findings. The types of publications include leaflets (*Research Highlights*), books, as well as proceedings of conferences organised by the HKSI. The team also publishes monographs, handbooks and leaflets for educational purpose. For example, some of the titles are:

- 《香港體育學院精英運動員支援服務手冊: 綜合性多元化訓練模式》 - A handbook on support services for elite sport in Hong Kong
- 《亞運會2014 - 運動員參賽心理手記》 - A handbook to help athletes mentally prepare for the Asian Games 2014
- 《高原訓練的新趨勢》 - A monograph on altitude training
- 《冠軍煮意》 - A cookbook with recipes that are suitable for athletes



Figure 7.10 A variety of scientific publications published



## CASE STUDIES

### Exchange with JISS and JSC

The HKSI signed a MOU with Japan Institute of Sports Sciences (JISS) in March 2011 and Japan Sport Council (JSC) in August 2016 to formalise a systematic cooperation between the two institutes in different areas of high performance training.

Following the signing of the MOU, the HKSI embarked on a series of projects which were very fruitful for both parties.

- The HKSI invited speakers from JISS and JSC to give presentations and conduct workshops at conferences organised by HKSI, including
  - Strength and conditioning seminar – *Movement quality: enhancing strength training efficiency for elite sports* (November 2011)
  - Talent identification development and education symposium (March 2013)
  - International scientific symposium – *Emerging technologies for sports performance enhancement* (March 2013)
  - International exchange forum on preparing athletes for 2016 Rio Olympics, sponsored by Mr Ming Wai Lau (December 2015)
- The HKSI sent speakers to give presentations and conduct workshops at conferences organised by JISS/ JSC, including
  - Asian conference on sport science 2011 – *Ten years of progress in sports sciences* (October 2011)
  - National network conference 2012 and meeting for collaboration in talent identification field (March 2012)
  - 1<sup>st</sup> International conference on athlete development pathway – *Meet the world-class athlete development models* (March 2014)
  - 2<sup>nd</sup> International conference on athlete development pathway – *Coaching as an enhancer of athlete pathway* (February 2015)
- Both the HKSI and JISS/ JSC recognise the importance of early identification of talented individuals and their development and are committed to the objective of talent identification and development, including
  - Colleagues from HKSI and JSC participated as invited speakers in symposiums organised by respective organisations
  - Two joint talent development camps for potential young athletes (fencing and badminton) from Japan and Hong Kong were organised (December 2013 and August 2014)
  - Athlete development pathway collaboration meetings held between the HKSI and JSC

- Exchange visits between coaches and staff in sports science, sports medicine and innovation to exchange knowledge, expertise and experience

## Exchange with Shanghai Sports Institute

The HKSI signed a MOU with Shanghai Sports Institute (SSI) in July 2010 to further enhance the scientific sports training and educational support to elite athletes in Hong Kong and Shanghai.

Following the signing of the MOU, the HKSI embarked on a series of projects which were very fruitful for both parties.

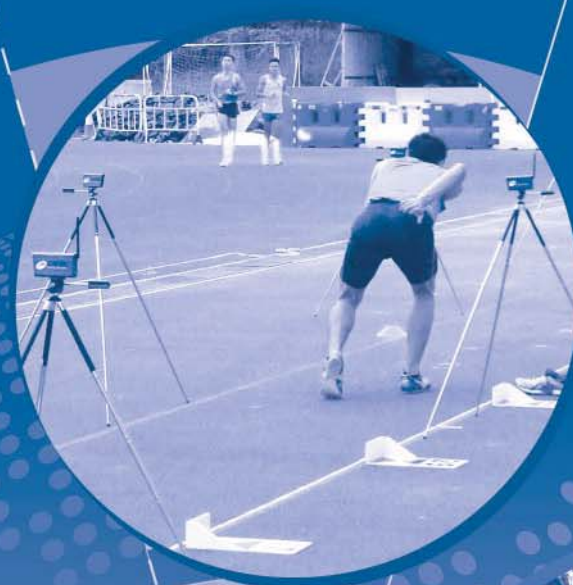
- The HKSI invited speakers from SSI to give presentations and conduct workshops at conferences organised by HKSI, including
  - Elite Training Seminar - *The use of psychology in sports* (December 2012)
  - Workshop on the lower body fitness training for junior wushu athletes (January 2013)
  - Hong Kong-Shanghai Strength and Conditioning Symposium - *Considerations for strength training in young athletes* (December 2013)
- The HKSI sent speakers to give presentations and conduct workshops at conferences organised by SSI, including
  - Shanghai-Hong Kong Strength and Conditioning Symposium - *Analysis and application on physiological and performance assessment* (October 2014)
- The HKSI and SSI jointly organised training programmes for athletes and professionals, including
  - NSCA certification courses and examinations in Hong Kong
  - SSI study tours
- Exchange visits between coaches and staff in sports science, sports medicine and innovation to exchange knowledge, expertise and experience

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An Integrated Multi-disciplinary Model**

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