PHYSICAL CONDITIONING THOUGH ACL REHABILITATION

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One of the biggest challenges for the athlete that suffers a long-term injury, such as ACL rupture, is to maintain the previous level of cardiovascular fitness and overall conditioning. Many athletes will lack either the time, the motivation, or the resources to supplement their rehabilitation sessions with attention to fitness training. Bridging the gap between the cardiovascular fitness and strength deficits and safely returning the athlete back to their sport is the focus of the physical coach at Aspetar.

When an athlete stops participating in high levels of physical activity because of an injury, the physiological changes that occur are usually referred to as detraining. Detraining is the partial or complete loss of training-induced adaptations, in response to an insufficient training stimulus. Detraining characteristics may be different depending on the athlete's training age (their history of training) and the duration of their training cessation[1].

Given that the injured athlete greatly reduces their physical activity levels, maintaining muscle mass whilst simultaneously avoiding gains in fat mass can be challenging. The magnitude of muscle loss during injury is an important concern for the athlete when considering the level and duration of rehabilitation required before returning to full functional capacity[2]. Two or three weeks of detraining have been shown to cause the following decrements in highly trained subjects: Muscle oxidative enzymes decreased by 13 to 24%, performance time decreased by about 2 to 5% and VO2max decreased by about 4%[3]. It is recommended to provide an exercise stimulus (especially resistance exercise) for the uninjured muscle groups (e.g., upper body) to prevent any unwanted reductions in regional lean mass that may subsequently affect whole body muscle mass and metabolic function[8].

The factors underpinning the reduction in VO2max depend on the duration of training cessation. They are mainly central maximal cardiac output (Qmax) during the first 3-4 weeks, and mainly peripheral afterwards, which relate to adaptations at the muscles that improve their ability to take on and process the oxygen. Considering that central adaptation and maladaptation are not specific to the trained muscles, alternative training can be implemented to avoid or limit detraining while an athlete is injured. For example, one leg cycling represents an exercise modality that can be used to limit the central effect of training cessation in injured athletes. Olivier et al. (2010) randomized 24 soccer players with ACL reconstruction in a control group that followed a classic rehabilitation program and an experimental group that added aerobic training of the non-operated leg to the rehabilitation program. Stroke volume and VO2max were maintained in the experimental group while they decreased by ~20 and 10% respectively in the control group. Arm cranking represents an alternative modality of cardiovascular training that is commonly used in the conditioning of spinal cord injury patients[5]. As we know oxygen transport to working skeletal muscles is challenged during whole-body exercise. When an athlete is using his upper body only, for example during arm-cranking exercise, this elicits a maximal oxygen uptake (VO2max) corresponding to approximately 70% of the value reached during leg exercises. Considering that, arm cranking allows us to reach exercise intensities that should be high enough to maintain or limit the decrease of Qmax[6].

A modified training program can avoid or reduce detraining. If an athlete can

Table 1

Test	Phase 1	Test	Phase 2	Test	Phase 3a	Test	Phase 3b	Test
-Body comp -UB strength -UB Cardio (UBE) -Core test battery	-Goal: back to physical activity, minimize detraining effect -UB strength focus on hypertrophy/ endurance -UB Cardio: Moderate intensity -Core: focus on the core muscle's stabilizing anatomical function	-Body comp -UB Strength -UB Cardio (UBE) -Core test battery -at 12w -Watt bike submax ramp test	-Goal: build up a solid foundation to support late-stage conditioning -UB strength: endurance/ strength -Cardio: moderate to high intensity low impact cardio exercises -Core focus on core muscles stabilizing and dynamic anatomical function	-Body comp -UB strength -Wattbike submax ramp test -Core test battery	-Goal: prepare athlete to RTS -UB strength: power/ strength Cardio: high intensity -Core: more dynamic functional exercises that require and challenge core stability	Yo-Yo test	-Goal: continue progression to RTS -Cardio: on field shuttle running -maintaining UB and core strength	Yo-Yo retest
4-6w post-op	2-3x/w	10w post-op	2-3x/w	18w post-op	2-3x/w	SPSP stage 3	3x/w	Discharge

Table 1: Outline of the athlete conditioning journey during ACL rehabilitation.

maintain a certain level of exercise, they can retain a greater percentage of their baseline fitness levels. The intensity and duration of this 'level of exercise' remains controversial, is specific to each sport and it will depend upon an athlete's baseline fitness level. Modified training strategies have been shown to delay the onset of cardiorespiratory, metabolic, muscular, and hormonal detraining. Maintaining training intensity seems to be the key factor but training volume can be reduced by 60 to 90%, training frequency reductions should be no more than 20 to 30% in athletes[7].

Regaining pre-injury levels of conditioning is essential for the athletes to optimize performance after returning to play. Similar to effective training programs, reconditioning programs also need to follow training principles. The time required to recover pre-injury neuromuscular and cardiorespiratory levels may highly vary among athletes based on several factors including: time of training stimuli cessation or reduction, amount of individual detraining-induced effects, individual fitness levels and sport-specific requirements[9]. Mindful of any post-surgical restrictions of weight-bearing status[10] our current practice at Aspetar is to introduce physical conditioning sessions for the rest of the body in the early phase of rehabilitation and some cases even prior to surgery to prevent deconditioning effects. The goal is to maintain cardiovascular fitness and increase the functional capacity of the athletes through the application of resistance training that does not compromise or risk the injured area.

Typically, the athlete is referred to the physical coach by the physiotherapist 3-4 weeks post-surgery. During the first session an assessment is performed to establish post-surgery fitness status and determine the parameters for training prescription. Assessments are being performed throughout the rehabilitation process at 6-week intervals, at the beginning and the end of each microcycle. These tests not only provide us with constructive feedback on athlete improvement, but they are also helping to motivate and set realistic training goals for the athlete. The training program is linear periodized, divided into 4 micro cycles, and designed by following the FITT-VP principles (Frequency -Intensity-Time-Type-Volume-Progression).

Physical conditioning is one of the 4 crucial aspects that need to be considered for the RTS (Movement quality, Technical and Tactical retraining, and Training load)[11]. Problems that exist following ACL surgery cannot be solved by one professional but a coordinated effort among the surgeon, physiotherapist, physical coach, and sport rehabilitator is required for successful rehabilitation and return to play.

A successful fitness outcome relies also on the long-term commitment of the athlete to complying with and completing the training program. The physical coach has an important role in educating the athlete about what is expected of them and what they can expect throughout the rehabilitation period.

PHYSICAL ASSESSMENT TESTS

Upper Body Strength tests

The Concept2 Dyno is a dynamometer that is reliable to assess the strength of the athletes[12] and is widely used by athletic clubs and the police force as well as by researchers for strength assessment[13,14].

Initial Strength Assessment (5 rep test)

1. Seated Bench Press
2. Seated Row

Upper body endurance test

- 1 min Push Ups

Core Stability tests

1. Trunk flexor endurance test
2. Trunk lateral endurance test
3. Trunk extensor endurance test
4. Prone bridge test.

Cardiovascular fitness tests

An incremental submaximal test on the upper body ergometer or leg cycle ergometer is used for the cardiovascular endurance estimation of the injured athletes during their initial assessment. The incremental exercise test is determined by different variables the starting stage, the consecutive work rates, the increments, the duration of each increment and the athlete's heart rate. These variables can be modified extensively to suit the purpose of the training program or the individual and have proved useful in identifying and monitoring individuals or team's adaptation to training[15].

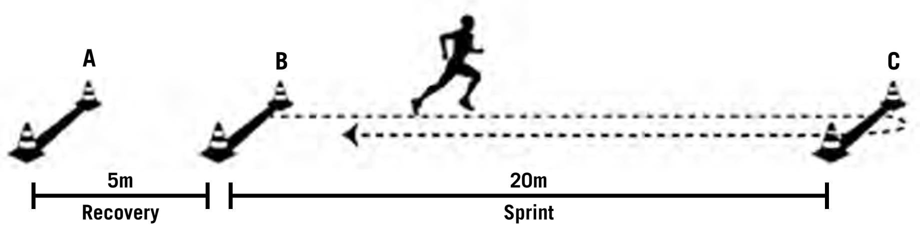

Figure 1: Objective of the Yo-Yo intermittent recovery test 1 is to assess aerobic capacity and recovery ability.

Submaximal performance testing is a way of estimating either VO2 max or aerobic fitness in sports medicine. The test protocols do not reach the maximum of the respiratory and cardiovascular systems. Submaximal tests are used because maximal tests can be dangerous in individuals who are inactive for a period due to injury. Options include:

Upper body ergometer (UBE) increment test

Outcome measures:

- Total time (min)
- Effort level (power/watt)
- Heart Rate (bpm)
- Heart rate recovery (1min/2min)
- Rate of Perceived Exertion (RPE)

Wattbike Increment submaximal test

Outcome measures:

- Total time (min)
- Maximum mean power (MMP)
- Power to weight ratio (w/kg)
- VO2max estimate (ml/kg/min)
- Heart rate (bpm)
- Heart rate recovery (1min/2min)
- Rate of Perceived Exertion (RPE)

Yo-Yo Intermittent Recovery test 1

Testing objective:

- To assess aerobic capacity and recovery ability

Outcome measures:

- Total time (min)
- Total Distance (m)
- Maximal Aerobic Speed (Km/h)
- Average Heart rate (bpm), Heart rate max (bpm), Heart rate recovery (bpm)
- Rate of Perceived Exertion (RPE).

The following is an example of a weekly development of on field running session we use, depending on the athletes' requirements to meet Phase 3b goals. (MAS=maximum aerobic speed).

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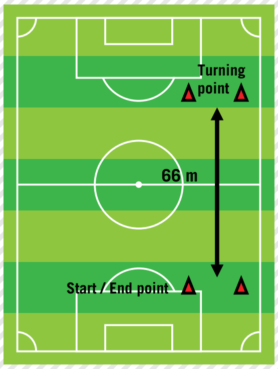
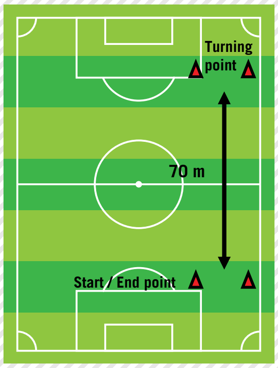
WEEK 1

Number of sessions	:	2
Running modality	:	Intermittent
Running intensity	:	100% MAS
Sets	:	3
Reps	:	8
Effort	:	30 sec (Shuttle)
Effort distance	:	132 m (2x 66 m)
Rec btw reps	:	30 sec (passive)
W:R ratio	:	1:1
Rest btw sets	:	2 min
Distance per set	:	1056 m
Total session distance	:	3168 m
Total week distance	:	6336 m



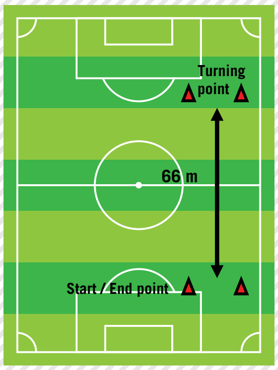
WEEK 2

Number of sessions	:	2
Running modality	:	Intermittent
Running intensity	:	105% MAS
Sets	:	3
Reps	:	8
Effort	:	30 sec (Shuttle)
Effort distance	:	140 m (2x 70 m)
Rec btw reps	:	30 sec (passive)
W:R ratio	:	1:1
Rest btw sets	:	2 min
Distance per set	:	1120 m
Total session distance	:	3360 m
Total week distance	:	6720 m



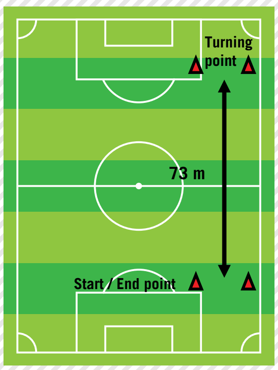
WEEK 3

Number of sessions	:	2
Running modality	:	Intermittent
Running intensity	:	100% MAS
Sets	:	3
Reps	:	7
Effort	:	30 sec (Shuttle)
Effort distance	:	132 m (2x 66 m)
Rec btw reps	:	15 sec (passive)
W:R ratio	:	1:0.5
Rest btw sets	:	2 min
Distance per set	:	924 m
Total session distance	:	2772 m
Total week distance	:	5544 m

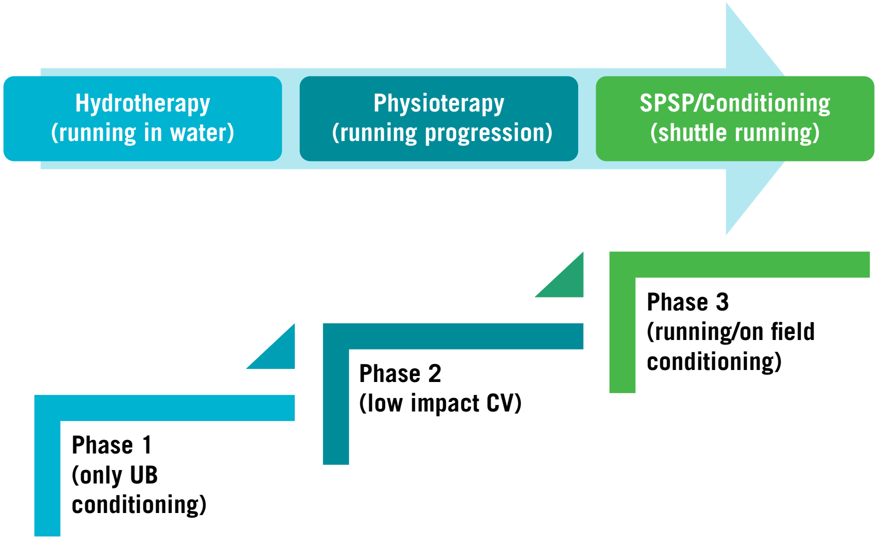


WEEK 4

Number of sessions	:	2
Running modality	:	Intermittent
Running intensity	:	110% MAS
Sets	:	4
Reps	:	8
Effort	:	15 sec (straight line)
Effort distance	:	73 m
Rec btw reps	:	30 sec (passive)
W:R ratio	:	1:2
Rest btw sets	:	2 min
Distance per set	:	584 m
Total session distance	:	2336 m
Total week distance	:	4672 m

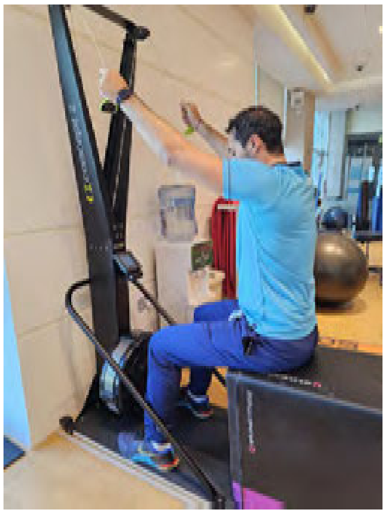


Below is shown the physical conditioning process through the 3 different phases carefully in line with the rehabilitation timeline to ensure a safe and continuous progress for the athlete from low impact to running.

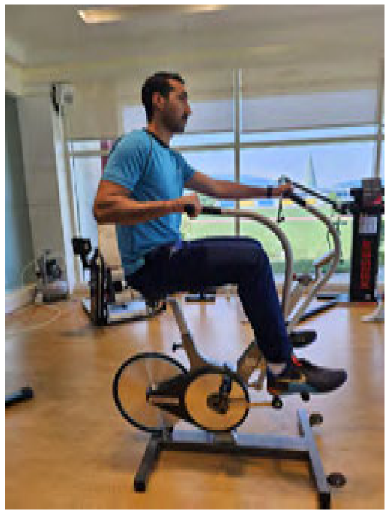


Upper body CV exercises (no impact)

Upper Body Ergometer (UBE)



Ski Erg sitting position

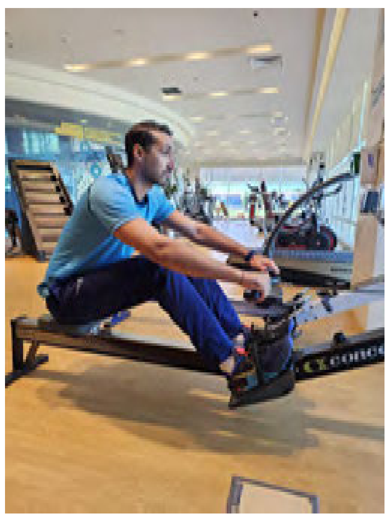


Keiser Air Dyne only hands

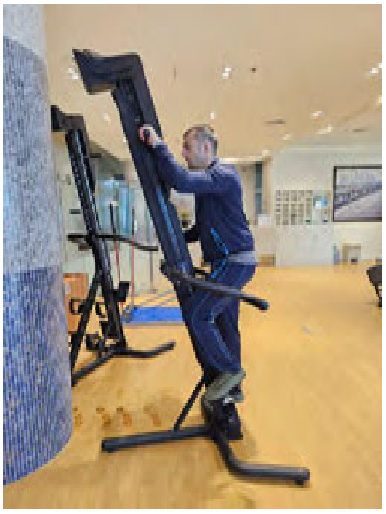
Progression of CV exercises from low impact to on field running

Elliptical

Stationary bike



Rowing



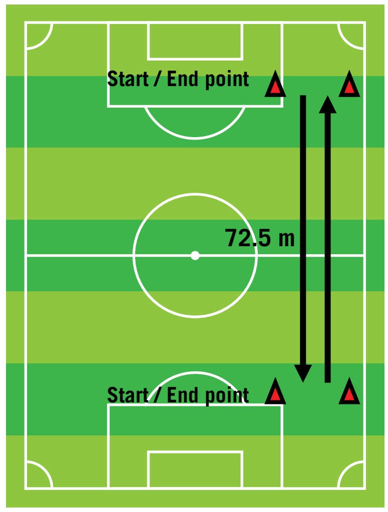
Versa climber

Stepper

Wattbike

Jacobs Ladder

Matrix staircase



On-field running

CONCLUSION

In Aspetar we see the early integration of conditioning after ACL injury as a vital component of the rehabilitation process to minimise deconditioning. The whole body must be targeted to better prepare the athlete physically and psychologically for the sport specific rehabilitation in preparation for return to play. Proper implementation of a post-injury training program requires regular assessment of the athlete, an understanding of the conditioning requirements of their sport and implementation training strategies that complement the recovery and rehabilitation of the injured limb. A well-designed conditioning program can prepare an athlete mentally and physically to optimize return to performance and complement the development of other physical qualities throughout the rehabilitation process.

References

Available at www.aspetar.com/journal

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