

# Introduction

How it all happend – started but never ends  
Back to the top with the 8 steps of rehabilitation  
*Doing the crucial right*



Profiler Huber  
Ski Alpin  
Saisonende für Vizeweltmeister Perut  
Kreuzbandriss und Meniskussschaden

The injury

sudden & unpredictable -  
the fall & the pain - the  
result a cruciate ligament  
tear & the end of the  
season

purposefully progressively  
planned therapy sessions  
with ups & downs

The  
Rehabilitation



„Weiß, dass es geht“  
Karlmoser verletztes Ski-Team Adrien Perut beginnt die Arbeit mit  
Comeback in Tignes. Schock ist verstanden, alle Verletzung macht Mut



The  
Comeback

long awaited & long  
prepared - the successful  
return to sport

accompanied by consistent  
& constant preventive  
therapy & training

The recipe for  
success of a  
sport career

The prevention  
The Golden  
Medal of health

It can happen so quickly from one moment to the next and it's already happened. This one technical error and these external environmental influences with icy, uneven slope or a wrong movement on the soccer field and the fall with diagnosis cruciate ligament rupture and the end of the season follows. Now there is no way back only this one way forward, which on the one hand should be really well thought out and planned and on the other hand is always ongoing so that such injuries do not occur again.

But what is behind it all and what does the way back into sports look like? Why it is enormously important to do the right things during rehabilitation and afterwards as a preventive measure, we explain to you in the following.

In the rehabilitation of an injury it is basically irrelevant whether you are a competitive athlete or not, the phases are always divided from one stage to the next. Each stage is considered as an independent hurdle to be mastered and in no way two stages are taken at once, this only leads to stumbling and tumbling back down to the lower stage. Time and patience play a decisive factor, the more conscientiously and consistently the therapy and training as well as the associated regenerative measures are completed in the individual stages, the better the transition to the next rehabilitation phase.

This also includes that the requirements for each individual rehabilitation stage should be checked and tested in order to accompany you in the best possible way on your way, to drive you and to be able to lead you back to your top performance in sports and everyday life. Decisive is also a good joint leadership and communication on the part of doctors, physiotherapists and coaches team, which we would like to show you here.

There are exactly 8 rehabilitation stages to distinguish, exactly 8 as infinite, because even after successfully completed rehabilitation it always goes on and now the prevention as rehabilitation stage 8 moves into the spotlight, so that the risk of a subsequent injury can be reduced. It is particularly important in rehabilitation stage 1 to complete an initial test of the healthy side of the leg to lay a foundation, if followed in stage 3, 5 + 6 these measurement results can then already be compared with the injured side and put into relation. The better, more precise and, above all, more targeted one works on the deficits and potentials from the beginning of the therapy, the more successfully one can set the green ticks on the checklist in the individual rehabilitation phases and approach one's goal piece by piece. Nevertheless, one should be aware that this rehabilitation path accompanied by people who work together with the highest precision and competence is not an easy path with shortcuts, it can be very individual with uphill and downhill passages. Below are the detailed rehabilitation contents in the individual phases. We wish a successful rehabilitation and way back!

# Criterion based ACL-Rehabilitation

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Phase 1: early post-operative phase

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Phase 2: late post-operative phase (ca. 4 week after full load)



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Phase 3: Strengthening and tendon orientation

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Phase 4: Strengthening plyometry



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Rehaphase 5: sportspecific run/jump training

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Phase 6: Return to Sport

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Phase 7: Return to Competition (soonest 9 month)



Phase 8: Secondary prevention



## Phase 1: early post-operative phase

Aims	Milestones
<ul style="list-style-type: none"> <li>○ Total extension</li> <li>○ Combating „Arthrogenic Muskel Inhibition (AMI)“</li> <li>○ Swelling reduction</li> <li>○ Reduce muscle atrophy</li> </ul>	<ul style="list-style-type: none"> <li>○ 20x Active Straight Leg Raise“ without „LAG-Sign“</li> <li>○ ROM 0-90°</li> <li>○ Full load</li> </ul>

### Content of therapy

<b>ROM</b>	<ul style="list-style-type: none"> <li>○ Patella mobilisation</li> <li>○ E/F mobilisation in permitted range – <b>focus extension</b></li> <li>○ Check hip and ankle mobility</li> <li>○ Scar mobilisation</li> </ul>
<b>AMI Combating</b>	<ul style="list-style-type: none"> <li>○ „Hamstrings fatigue“ + reactivation Vastus Medialis Obliquus (VMO)</li> <li>○ Electromyography (EMG): control and activation Quadrizeps with Biofeedbacktraining</li> <li>○ Swelling reducing measures</li> <li>○ Neuromuskuläre Electrostimulation (NMES):Kneepacemaker, Blood Flow Restriction Training (BFRT)</li> <li>○ Cooling: Game Ready, Kryofluid</li> </ul>
<b>Gait</b>	<ul style="list-style-type: none"> <li>○ Gait training and analysis</li> </ul>
<b>Water therapy</b>	<ul style="list-style-type: none"> <li>○ Complete wound healing of skin</li> </ul>
<b>Blood Flow Restriction Training (BFR)</b>	<ul style="list-style-type: none"> <li>○ Passive 100% arterial occlusion</li> <li>○ Passive 80% arterial occlusion combined with NMES</li> <li>○ Aktive 80% arterial occlusion</li> </ul>
<b>Strengthening OP leg (load permit)</b>	<ul style="list-style-type: none"> <li>○ Coordinative strength training: 10-15reps, 2-4 sets (10% 1 RM)</li> <li>○ Example: <b>bipedal</b> Calf raises, High Squats, Good Mornings, ... (if 50% of body weight is permitted)</li> </ul>
<b>Strengthening whole body</b>	<ul style="list-style-type: none"> <li>○ Training of healthy leg in strength endurance method (3x13-20, 40-60% 1RM)</li> <li>○ Core strength training</li> <li>○ Training upper body (especially thrower athletes important + throwing/striking exercises in sitting position)</li> </ul>
<b>External focus</b>	<ul style="list-style-type: none"> <li>○ Virtual reality (VR), Neuroathletic, Blaze Pods...</li> </ul>

### MOTUM Tests: Elevation of basic tests

- Healthy leg isokinetic test con/con 60°/s, isometric 60° E/F
- Elite ski racing athletes: additional eccentric hamstrings 60°/s
- Elite team sports: additional eccentric hamstrings 60°/s + isokinetic con/con 180° + 240°/s
- Healthy leg in closed chain: isometric single leg squat on force plate

*CAVE: if 4 weeks post operation no improvement of E – contact medical doctor*

## Phase 2: late post-operative phase (ca. 4 week after full load)

Aims	Milestones: 4 Weeks full load
<ul style="list-style-type: none"> <li>○ Normal gait</li> <li>○ Reduce swelling despite progression of load</li> <li>○ Normal step up and down</li> <li>○ Stabilize AMI</li> <li>○ Ride ergonomically</li> <li>○ Possible ADL</li> </ul>	<ul style="list-style-type: none"> <li>○ Simple gait analysis Motum on treadmill – normal gait with IMU's OS/US – self selected velocity</li> <li>○ Y-Balance anterior Reach LSI Diff 8cm +/- IMU's, if gait analysis</li> <li>○ Isometry LS-Index healthy/OP in 60° KF: extensor/flexor – OP- leg as criterion NRS 5/10 as stop criterion LSI ≥ 70% (Bousquet et al 2018 hat 80%)</li> <li>○ KOS-ADL ≥ 60%</li> </ul>
Content of therapy	
<b>Strengthening OP leg</b>	<ul style="list-style-type: none"> <li>○ Strength endurance training: 13-20reps (40-60% 1RM), 3-4 sets</li> <li>○ Exercise examples: Squats, Good Mornings, Calf raises, Split Squats, Step up/down, Leg press (1bg), 1bg Squats/Deadlift</li> <li>○ Endurance               <ul style="list-style-type: none"> <li>● Ergometry or Crosstrainer</li> </ul> </li> <li>○ Coordination training: balance training with instable surfaces</li> </ul>
<b>Blood Flow Restriction</b>	<ul style="list-style-type: none"> <li>○ dynamic, 80% arterial occlusion LOP, 30/15/15/15 Wh mit 30sec pause, 20-30% 1RM</li> <li>○ ergometry, 80% LOP, 5-20 min, 50% Heart rate, possible interval training</li> </ul>
<b>Strengthening whole body</b>	<ul style="list-style-type: none"> <li>○ Training of healthy leg in strength hypertrophy method - 4x8-12reps, 60-80% 1RM</li> <li>○ Core strength training</li> <li>○ Training upper body (especially thrower athletes important + throwing/striking exercises in sitting position)</li> </ul>
<b>Virtual Reality</b>	<ul style="list-style-type: none"> <li>○ Training external focus</li> </ul>
<b>Standard measures</b>	<ul style="list-style-type: none"> <li>○ Biofeedbacktraining EMG, continue NMSE</li> </ul>
MOTUM tests	
<ul style="list-style-type: none"> <li>○ 3D-gait analysis with IMU's</li> <li>○ 3sec single leg stance on force plate with 45° knee flexion</li> <li>○ Isokinet Isometric</li> <li>○ KOS-ADL questionnaire</li> </ul>	

## Phase 3: Strengthening and tendon orientation

Aims	Milestones: 10-12 Weeks full load
<ul style="list-style-type: none"> <li>○ Full ROM</li> <li>○ Muscle growth</li> <li>○ Tendon capacity and preparation for plyometric training</li> <li>○ Improve cardiac capacity</li> </ul>	<ul style="list-style-type: none"> <li>○ LS-Index <math>\geq 80\%</math> in isometric strength testing 60° F on Isokinet for flexors/extensors (Bousquet et al, 2018)</li> <li>○ KOS-ADL 70%</li> <li>○ Isometric Single leg Squat in 60° and 150% of body weight (Buckthorpe &amp; Della Villa, 2020)</li> <li>○ Y-Balance Test <math>\geq 90\%</math> of Composite Score (Bousquet et al 2018) Norm values anterior Reach</li> </ul>
Content of therapy	
<p><b>Strengthening OP leg</b></p>	<ul style="list-style-type: none"> <li>○ Hypertrophy training</li> <li>○ Exercise examples: same exercises + Front-/Side lunges, <b>focus on single leg</b></li> <li>○ Build up on tendon load: slow motion and velocity + high load               <ul style="list-style-type: none"> <li>● „Heavy Slow Resistance Training“</li> <li>● „Fibrozyt-Growing- Factor Methode“</li> </ul> </li> <li>○ Endurance basic 1 on ergometry</li> </ul>
<p><b>Strengthening whole body</b></p>	<ul style="list-style-type: none"> <li>○ Training of healthy leg in strength hypertrophy method</li> <li>○ Core strength training</li> <li>○ Training upper body (especially thrower athletes important + throwing/striking exercises)</li> </ul>
MOTUM tests	
<ul style="list-style-type: none"> <li>○ Isometric strength test for flexor and extensor on Isokinet</li> <li>○ Isometric „Single Leg Squat“</li> <li>○ Y-Balance test</li> <li>○ KOS-ADL questionnaire</li> </ul>	

## Rehaphase 4: Strengthening plyometry

Aims	Milestones
<ul style="list-style-type: none"> <li>○ Tolerance of load for developing run and jump movement pattern</li> </ul>	<ul style="list-style-type: none"> <li>○ QS-Index <math>\geq 70\%</math> isokinetic strength testing on Isokinet for flexors/extensors</li> <li>○ Both legged/single leg „Counter Movement Jump“ on force plate <math>\geq 70\%</math> LSI</li> <li>○ KOS-ADL <math>\geq 75\%</math></li> <li>○ „Single leg hop for distance“ LSI time for stabilisazion (<math>\leq 1,12s</math>), bilateral „hop for distance“ LSI time for stabilisazion (<math>\leq 0,81s</math>)</li> <li>○ Y-Balance Test</li> </ul>
Content of therapy	
<p><b>Content of training</b></p>	<ul style="list-style-type: none"> <li>○ Jump development</li> <li>○ Run ABC</li> <li>○ Continue on strength training: power/explosive strength</li> <li>○ Strengthening whole body</li> <li>○ Continue on endurance on ergometry:               <ul style="list-style-type: none"> <li>Basic 2                   <ul style="list-style-type: none"> <li>• extensive interval</li> <li>• intensive interval</li> </ul> </li> </ul> </li> </ul>
MOTUM tests	
<ul style="list-style-type: none"> <li>○ Isokinetic test for flexors/extensors on Isokinet</li> <li>○ Single leg „Counter Movement Jump“ on force plate</li> <li>○ „Single leg hop for distance“ – stabilization time on force plate</li> <li>○ KOS-ADL questionnaire</li> </ul>	

## Phase 5: sport specific run/jump training (earliest after 6 month)

Aims	Milestones
<ul style="list-style-type: none"> <li>○ Agility</li> <li>○ Run/jump development</li> <li>○ Sportartspezifische Drills</li> <li>○ Implementation of secondary injury prevention</li> </ul>	<ul style="list-style-type: none"> <li>○ Back in Action test 1               <ul style="list-style-type: none"> <li>● Nominal values <math>\geq</math> NORM in all tests, Isokinet LSI <math>\geq</math> 80%</li> <li>● Elite athletes with sport specific importance of nominal values                   <ul style="list-style-type: none"> <li><b>Females football:</b> E: 2,60 Nm/kg F:1,39Nm/kg</li> <li><b>Males football:</b> E: 3,28Nm/kg F: 1,91Nm/kg</li> <li><b>Males Ski Alpin:</b> E:3,31Nm/kg F:1,95Nm/kg</li> </ul> </li> </ul> </li> <li>○ KOS-ADL <math>\geq</math> 80%</li> <li>○ ACL-RSI <math>\geq</math> 60%</li> </ul>
Content of therapy	
<b>Content of training</b>	<ul style="list-style-type: none"> <li>○ Sport specific training</li> <li>○ Progression of intensity and amount of running until jumping development</li> <li>○ Sport transfer of training: agility/speed/change of direction with external focus               <ul style="list-style-type: none"> <li>„Speedcourt MOTUM“</li> <li>“Virtual Reality MOTUM“</li> </ul> </li> <li>○ Sportspecific endurance training</li> </ul>
MOTUM tests	
<ul style="list-style-type: none"> <li>○ Back in Action test on Isokinet</li> <li>○ KOS-ADL questionnaire</li> <li>○ ACL-RSI questionnaire</li> <li>○ Sportspecific additional tests, if necessary individual adapted</li> </ul>	



## Rehaphase 6: Phase Return to Sport

Aims		Milestones	
<ul style="list-style-type: none"> <li>○ Development of sportspecific load p.e. back on snow, team training on court/field</li> <li>○ Rebuild fitness level before injury and better</li> </ul>		<ul style="list-style-type: none"> <li>○ Back in Action Re-Test</li> <li>○ Isokinet LSI <math>\geq 90\%</math></li> <li>○ Nominal value depending on sport</li> <li>○ KOS-ADL <math>\geq 90\%</math></li> <li>○ ACL-RSI <math>\geq 70\%</math></li> </ul>	
Content of therapy			
Content of training		<ul style="list-style-type: none"> <li>○ implementation of sport performance</li> <li>○ Regular implementation of secondary prevention measures</li> </ul>	
MOTUM Testungen			
<ul style="list-style-type: none"> <li>○ Back in Action Re-Test with Isokinet</li> <li>○ Sportspecific additional tests, if necessary individual adapted</li> <li>○ KOS-ADL F questionnaire</li> <li>○ ACL-RSI questionnaire</li> </ul>			

## Phase 7: Return to Competition (soonest 9 month)

Aims		Milestones	
<ul style="list-style-type: none"> <li>○ Development of sportspecific load and competition mode</li> </ul>		<ul style="list-style-type: none"> <li>○ Back in Action test – all values better or same as pre-Injury values (if present)</li> <li>○ Retrieve performance at competition</li> </ul>	
Content of therapy			
Content of training		<ul style="list-style-type: none"> <li>○ Unlimited sport performance in daily competitive life</li> <li>○ Regular implementation of secondary prevention measures</li> </ul>	

## Phase 8: Secondary prevention

Content of therapy			
Content of training		<ul style="list-style-type: none"> <li>○ Diverse norm data</li> <li>○ Isokinet sportspecific normdata: male: extensors 3N/kg of body weight, flexors 2N/kg</li> </ul>	