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Summary Papers

Energy System Requirements of Alpine Ski Racing

by Troy Flanagan, Ph.D

Alpine ski racing is a physically demanding sport that requires a sustained high intensity energy supply to the muscles for over 2 minutes. The body has three systems available that can provide energy during skiing: the ATP-CP system, the anaerobic glycolysis (carbohydrate) system and the aerobic system (carbohydrate or fat). The contribution of these systems can change as the race progresses, depending on its intensity and duration. Each of these systems can provide energy for exercise at different rates and have different biochemical processes.

To date, there have been only a few studies examining the different contributions from each of these systems during the different disciplines of competitive alpine ski racing. For a coach, it is really important to have an in-depth knowledge of these systems in order to assess if the training programs are delivering the right stimulus and to ensure that a sports-specific training program is developed to improve the delivery of energy from the systems used during alpine ski racing.

The systems

The systems can be divided into aerobic or anaerobic. Aerobic means the production of adenosine triphospate (ATP) for muscle contraction in the presence of oxygen. Anaerobic is the development of ATP without the presence of oxygen.

More specifically, the systems can be broken down further into four:

1. ATP-phosphocreatine (ATP-PC) – the production of ATP from creatine phosphate
2. Anaerobic Glycolytic (lactic acid system) – the production of ATP from carbohydrate without the use of oxygen
3. Aerobic Glycolytic- the production of ATP from carbohydrate in the presence of oxygen
4. Aerobic Lipolytic – the production of ATP from fat in the presence of oxygen

Contribution of the systems to different duration skiing events

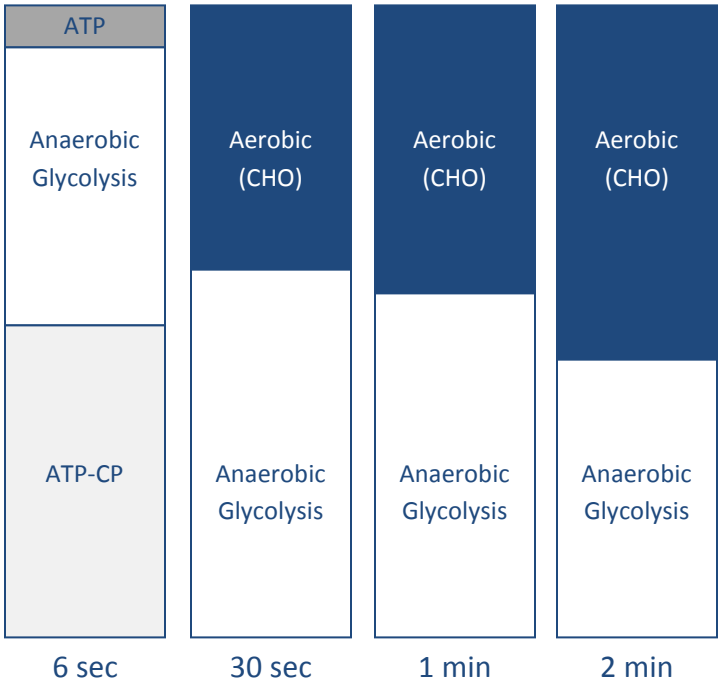
Alpine ski racing starts out primarily anaerobic for the first 30 seconds and then transitions to a mix of aerobic and anaerobic at around the one minute mark. As the race progresses and the anaerobic system starts to decline, the energy contribution becomes more and more aerobic. Interestingly, although the sport is traditionally viewed as anaerobic, the last thirty seconds of a race is primarily aerobic. Table 1 describes the change in contributions from the two systems during exhaustive exercise lasting 2 minutes. Figure 1 also describes a more detailed breakdown from each of the energy systems.

Table 1: The change in the contributions of the aerobic and anaerobic systems during exhaustive exercise lasting 2 minutes (similar to alpine ski racing)

Time period	*Anaerobic (%)*	*Aerobic (%)*
First 30 seconds	80	20
Second 30 seconds	60	40
Third 30 seconds	42	58
Last 30 seconds	33	66

Adaped from Bangsbo et al. 'Anaerobic energy production and O_2 deficit-debt relationship during exhaustive exercise in humans' – *Journal of Physiology* 422: 539-59, 1990

Figure 1: Contributions of different energy systems to the requirements of 2 minutes of high intensity exercise



Adapted from Hawley and Burke 'Peak Performance: Training and nutritional strategies for sport', Allen & Unwin, Sydney, 1998.

Fatigue

Fatigue is defined as a decline in the ability to sustain a predetermined force or tension. There are two types of fatigue – central and peripheral. Central fatigue is fatigue of the brain, spinal cord and the ability of the peripheral nerves to excite muscles. Peripheral fatigue is a decline in energy substrates (e.g., muscle glycogen), increase in metabolites and impaired ion regulation. Both central and peripheral fatigue impair the muscle activation and excitation-contraction coupling and reduce muscle power output. In alpine skiers, fatigue is likely to come from depletion of creatine phosphate, muscle glycogen in fast twitch fibers and an accumulation of muscle acidity. It is likely that there is more peripheral fatigue going on than central fatigue in alpine ski racing.

It is important to note that the mechanisms around fatigue of the anaerobic system remain hotly debated in the scientific literature. It is complex and multifactorial.

How to best train the different systems

While there are many ways to achieve high levels of fitness in alpine skiers, examination of the energy systems used in the sport is the best place to start. By looking at the contribution from each energy system, you can determine the importance of training each of the different energy systems. Since the sport of alpine skiing starts out maximally anaerobic and progressively becomes more aerobic as the race goes on, it is important that athletes have a good mix of aerobic and anaerobic fitness. The different types of fitness take varying lengths of time to develop. For example, anaerobic adaptations are much faster than aerobic adaptations (building of mitochondria, capillary density, aerobic enzyme concentration in the muscles and the ability to consume oxygen).

Table 2 outlines a variety of events ranging from high intensity short duration efforts through to events greater than 90 minutes and their associated energy systems, fuel and the typical way to train for each of those events.

Table 2: The energy systems used during exercise and the best type of workouts to train them

Event duration	System	Fuel	Training objective and best type of workouts
6 sec or less	ATP-CP	ATP and CP	Development of explosive power Sprint starts and max sprints (<6 sec) with Complete recovery (3-5 min) Power/resistance training (3 x 3-5 reps @ 95% max)
30 sec or less	ATP-CP Anaerobic glycolysis	ATP and CP Muscle glycogen	Lactate tolerance sprint repetitions (<30 sec) with long (3-5 min) rest Power/resistance training (3 x 8-10 reps @85% max)
15 min or less	Anaerobic glycolysis Aerobic	Muscle glycogen Blood glucose	Development of maximal aerobic power maximal steady state reps (5-10 min) with short recovery (1 min)
15-60 min	Aerobic	Muscle glycogen Blood glucose	Lactate threshold max stead state reps (as above) Sustained exercise at best aerobic pace
60-90 min	Aerobic	Muscle glycogen Blood glucose Triglycerides	Development of fatigue resistance sustained moderate to high intensity exercise
>90 min	Aerobic	Muscle glycogen Blood glucose Triglycerides	Development of endurance prolonged low to moderate exercise

Adapted from Hawley and Burke 'Peak Performance: Training and nutritional strategies for sport', Allen & Unwin, Sydney, 1998.

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Strength Assessment for Alpine Skiing

Bob Poehling

Strength and power assessments are a critical aspect of strength and conditioning and sports science. These assessments can be used in a variety of ways, including monitoring training progress, talent identification, and quantifying physical qualities. There is a tendency to overload on the amount of information collected during assessments. The assessment process should be kept simple and minimally invasive to the athlete's training program. At the same time, the assessments chosen should be reliable, valid and specific to the physiological demands of the sport. A wide array of technology can be used to assess athletes, ranging from force plates and linear position transducers to simple jump-and-reach measures. Results should be tracked over time to easily see areas of improvement and areas that need more specific attention.

Assessment Considerations

It is advantageous to use multiple technologies to assess the physical qualities of our athletes depending on the sport. The assessment of alpine skiers commonly uses a heart rate monitor, lactate analyzer, force plate and linear position transducer to create a full physiological profile for the athlete. This equipment can be expensive, but provides the tools for in-depth analysis of alpine skiers. For junior-level skiers, it is appropriate to begin with field-based tests of general aerobic capacity or strength. A testing protocol such as the SkillsQuest Fitness Testing Protocol provides a detailed protocol to follow with minimal equipment.

There are a number of ways to implement assessments into training programs. A full physiological assessment can take up to a complete day to perform all of the tests and entirely analyze the results. It is important to weigh the time and cost of extensive physiological testing against resource allocations in other areas. A very simple strategy is to track common exercises you use in your programming and have specified "target" days to set a new 5RM, for example. This approach can still easily shows gains made in specific physiological areas based on the exercises used.

The use of testing results should be strongly considered when planning such resource-intensive protocols. The results collected should be used to direct, guide and modify training programs. If you are not using the testing results to modify training, then you should reconsider your testing battery. It is useful to also compare results against other normative data for motivational purposes and to identify areas that need improving.

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Mobility and Overhead Squat Assessment

Tschana Schiller

Today's athletes are working harder than ever to become stronger, fitter, and healthier. In addition to creating more efficient and more powerful movements, this training should hopefully reduce the risk of injury and lead to a longer, more successful career. There are many cases, however, where athletes are regularly performing high-level activities with inefficiencies in their basic movement patterns. Recognizing the fundamental mobility or stability issues and then creating a program that allows athletes to address 'weak links' should allow the individual to perform better not only in their dry-land training programs, but ideally allow them to explore full range of movement, body control, and body awareness in many different sport positions. Performing regular mobility screens, especially utilizing movements such as a fundamental Overhead Squat, should give the tester great insight into how the athlete moves. It also allows the tester to be aware of tendencies that may lead to inefficient patterns, red flags for potential injury, or areas that need to be emphasized in the athletes training program.

Overhead Squat Mobility

The Overhead Squat Mobility exercise is a functional test that can be administered very quickly and for a large group of athletes in a single session. It also requires very little equipment and space to complete. It is very important, however, to remember that this test or other mobility tests that may be involved in the Functional Movement Screening process are not to be utilized as a tool to make a diagnosis. Rather, it is a useful tool to find an individual's weak links in their movement patterns. Diagnosing injuries or making medical assessments should be left up to a qualified medical professional. If at any time during the test an athlete complains of pain anywhere in the body, the test should be stopped, and the athlete should be referred to the medical staff for further assessment before continuing the screen.

The purpose of assessing an Overhead Squat is to look at a simple movement that is performed regularly in daily life and many different sports. The squat movement utilizes the entire lower body and is the start of most 'ready' positions for sport. A deep squat will allow the tester to look at symmetry and mobility of the ankles, knees, and hips. By having the athlete place a stick overhead, you will also be able to assess mobility in the shoulders and thoracic spine. An athlete with the ability to perform a deep squat successfully can be a good indicator of that individual's overall movement quality (Cook, 2003). If an athlete cannot perform a deep squat without compensations or adjustments, this can typically be attributed to an asymmetry or an overall stiffness in one part of the kinetic chain, or the way those pieces move together through the kinetic chain.

If the athlete has an asymmetry or has developed a poor motor pattern on one side of the body, the body's natural tendency is to correct this by compensating in other segments of the body. This can eventually lead to a break down or overuse in other muscles, tendons, or ligaments that can lead to an injury and keep the athlete out of training for a certain time period. If an asymmetry is observed during the Overhead Squat Mobility test, certain corrective exercises or stretches can be administered to help re-teach the athlete to have more efficient movements. Improving the deep squat will help an athlete get into a more athletic position and provide a good starting base for efficient, explosive, and forceful movements to utilize and transfer to sport training.

Performing an overhead squat is a complex movement where an athlete must have stability in the trunk, and mobility throughout the body while changing positions. The trunk and limbs must work together in a specific pattern in order to perform the movement correctly (Cook, 2003). The athlete must also maintain balance and stabilization as the movement is performed making this a useful way to find mobility or stability issues in an athlete.

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Periodization of the Alpine Season

Toni Beretzki

The periodization of the training year for alpine ski racing is very complex. Planning should include the development of both general athletic development and sport/ski specific development.

May-July

The training year begins with developing general athletic base levels of fitness between May – July. These three months are characterized by building up a high level of general endurance in the low intensity training categories (A1 and A2). This endurance ensures that the athletes can withstand a high ski volume on the hill during the competition season. This also improves the quality of training, competing, recovery and improves recovery and technical skill. During this general preparatory phase, strength endurance, core strength, proprioception and balance is also developed. Benchmarks for this phase for aerobic fitness are measured using a progressive bike test (5 min stages from 80W with 40W increments).

August - September

The next stage is on-hill camps between August – September. During this phase, the previous skills developed are maintained. The focus of these camps is biomechanical analysis of skiing technique and muscle sling workouts. The biomechanical analysis determines deficiencies or weakness of different sides of the body during skiing. Corrective exercises are implemented during this phase.

October

The focus of October is to continue to maintain endurance (A1-A2) and to build up A3. The main objective of this period is to develop a ski-specific strength- endurance base. Athletes regularly work out in the 4-6 mmol/L lactate range. Overall lifting circuits as well as ski-specific movement patterns are developed. There is a high priority on dynamic core and g force resistance training. We try to imitate the g forces in dry land training, since these forces affect athletes in their turns and jumps. Other sports specific actions can be developed like starts.

Competition Period

During the competition period athletes mainly work in the endurance A1 to promote recovery. This helps to help maintain the aerobic base and ensure that the skiing quality is high. Athletes average around 12 hours of A1 spinning weekly during the competition season. Maintenance of core function and muscle sling skills and proprioception is also important. It is useful to do a short slack line session before the athletes put on their skis in the morning.

Other considerations

Periodization of lifestyle is something which is sometimes neglected. As a professional athlete, the daily routine is important for biorhythms and success training. By training twice daily, the athlete has to consider recovery and nutrition. After a good breakfast in the morning and a training session in the morning, athletes are encouraged to rest for 20 minute and then start immediately with a healthy lunch. Lunch should be followed by another rest and short nap. After the second session, refueling starts immediately. This type of nutrition program ensures a maintenance of energy. Sleep is also an important consideration. At least 8-9 hours of sleep and a daily intake of 5000-6000 kcals is recommended. Recovery status can be monitored using various things from basic questionnaires through to blood tests for markers like CK, urea and ammonia. These variables can give a coach a good indication if the athlete is fatigued, exhausted or ready for the next day of training.

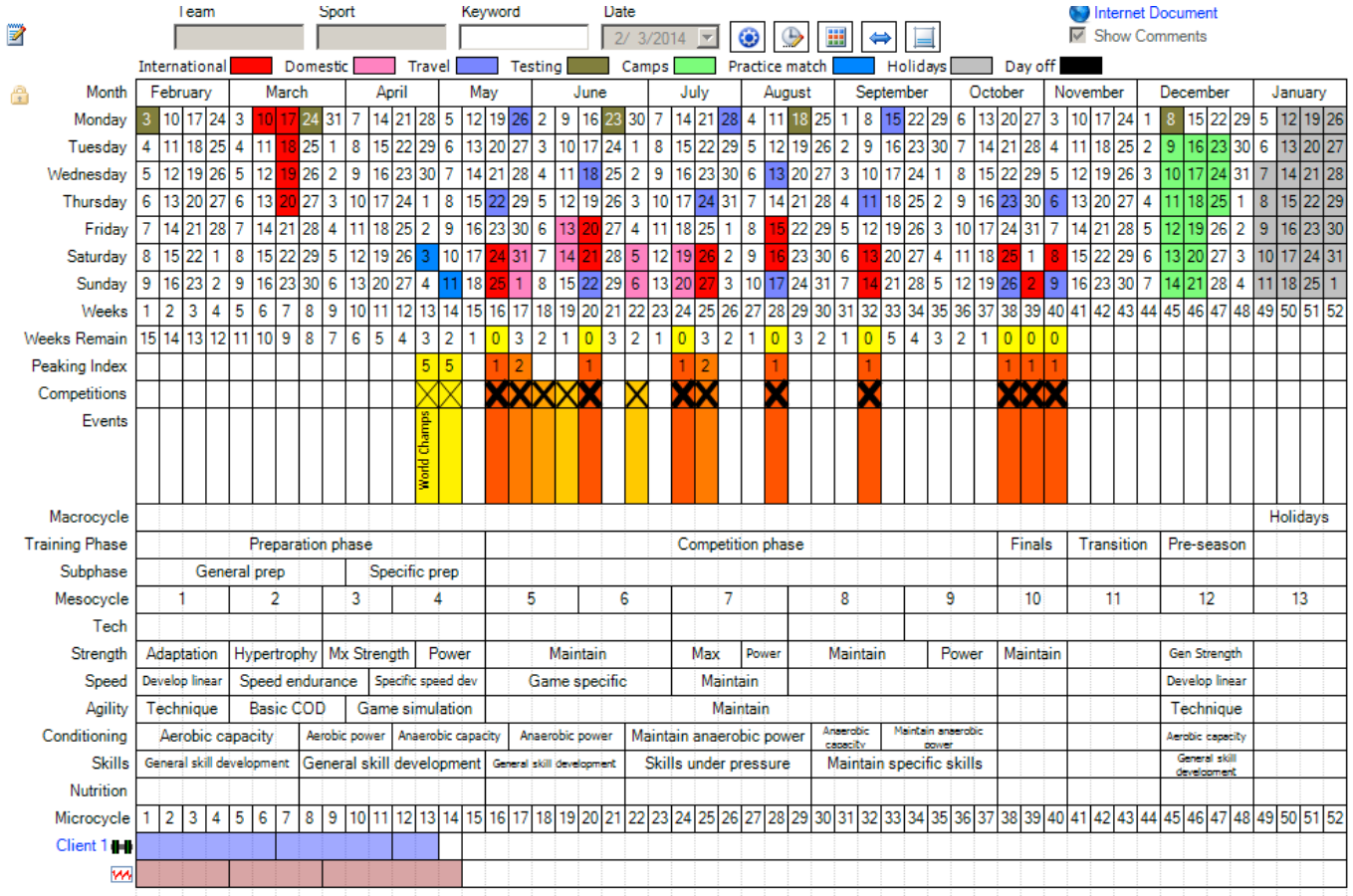
Training Software & Program Analysis

Chad Gerhard, Sports Physiologist

The use of training software in athletics is a key element when prescribing a periodized plan to the athlete. With the use of training software coaches can systematically and safely prescribe sessions for the athlete. Training software can also keep track of sessions and be used as a database for reference. At the United States Ski & Snowboard Association, we use several pieces of training software. Our High Performance Department uses Visual Coaching Pro to develop training programs for our athletes. Visual Coaching Pro has several capabilities that allow coaches to train their athletes from any location. Visual Coaching Pro provides a database of over 6,000 exercises. Along with the preloaded movements, coaches have the capability to film custom exercises that are specific to their sport. We can develop annual plans that outline an entire year of training. From the annual plan, we then prescribe specific weekly plans within various training blocks. Daily programs are then outlined and delivered to our athletes via an online application. Athletes can access their program via any smartphone. The second piece of training software that is used at the United States Ski & Snowboard Association is the Athlete Management Platform (AMP). With AMP, coaches can effectively and easily communicate important information regarding their team to everyone involved with any specific athlete. AMP allows us to share information, and track the progress of our athletes. Coaches can share research articles, injury notifications, and any piece of information that they feel is relevant to the sport or athlete.

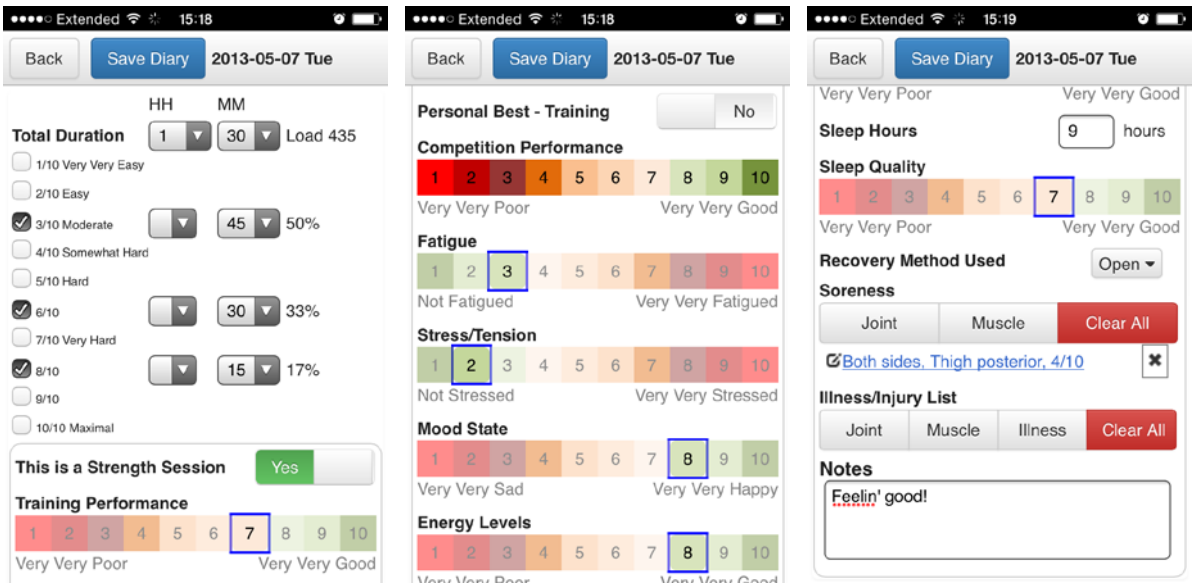
Benefits of training monitoring and analysis

The ability to monitor training and analyze programs is critical to the process of quantitating training periodization plans. Without program analysis, coaches have a limited idea of what they are prescribing, as well as what the athlete is actually experiencing. We are able to analyze athlete's programs using Visual Coaching Pro as well as Athlete Management Platform. One of the key features of Visual Coaching Pro is the ability to enter diary information. After completing a training session, athletes can open their VCP diary and within minutes provide coaches valuable information, which includes fatigue levels, session RPE, stress, energy levels, and amount of sleep. This information is then used to assess the training. Coaches then have the ability to analyze numerous variables including what they prescribed, and what was actually done. The AMP program has a similar feature. The Training Center feature in AMP allows coaches to categorize and interpret on hill training. Coaches can track the type of training, number of runs, RPE, and time. This can also be analyzed and graphed.



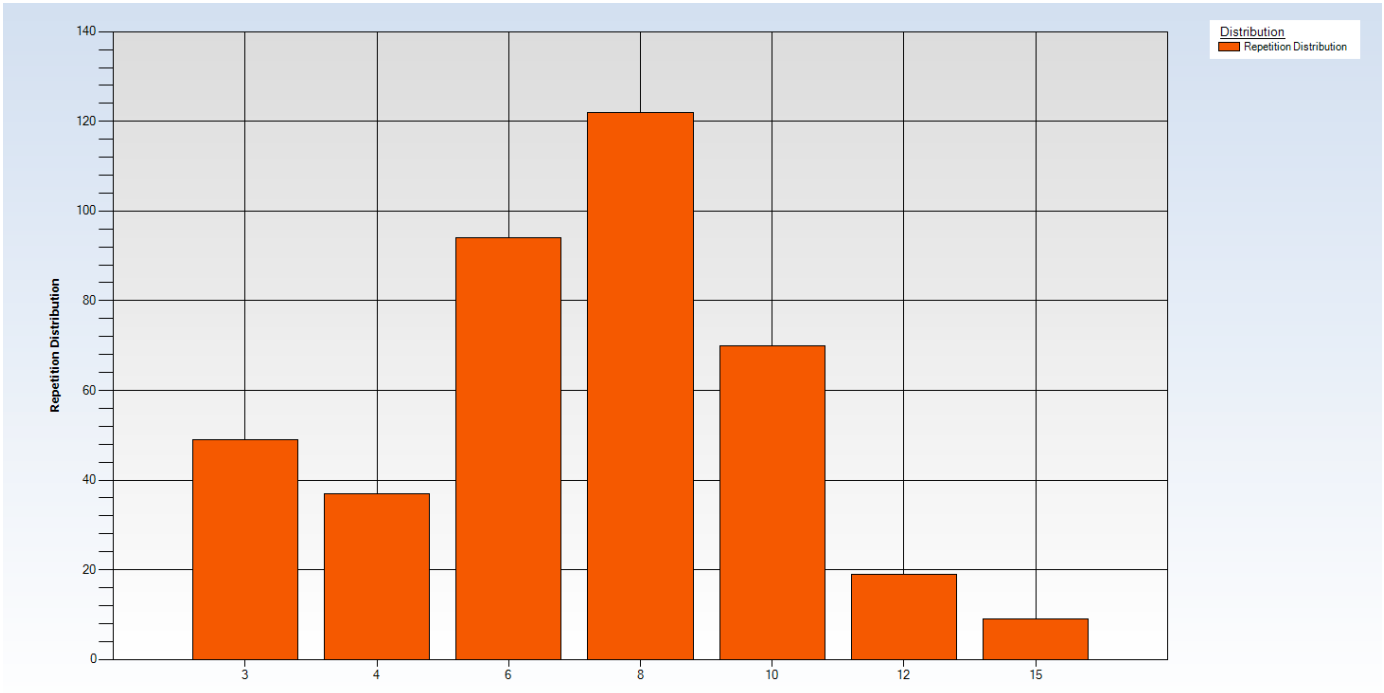
Capturing data on athletes

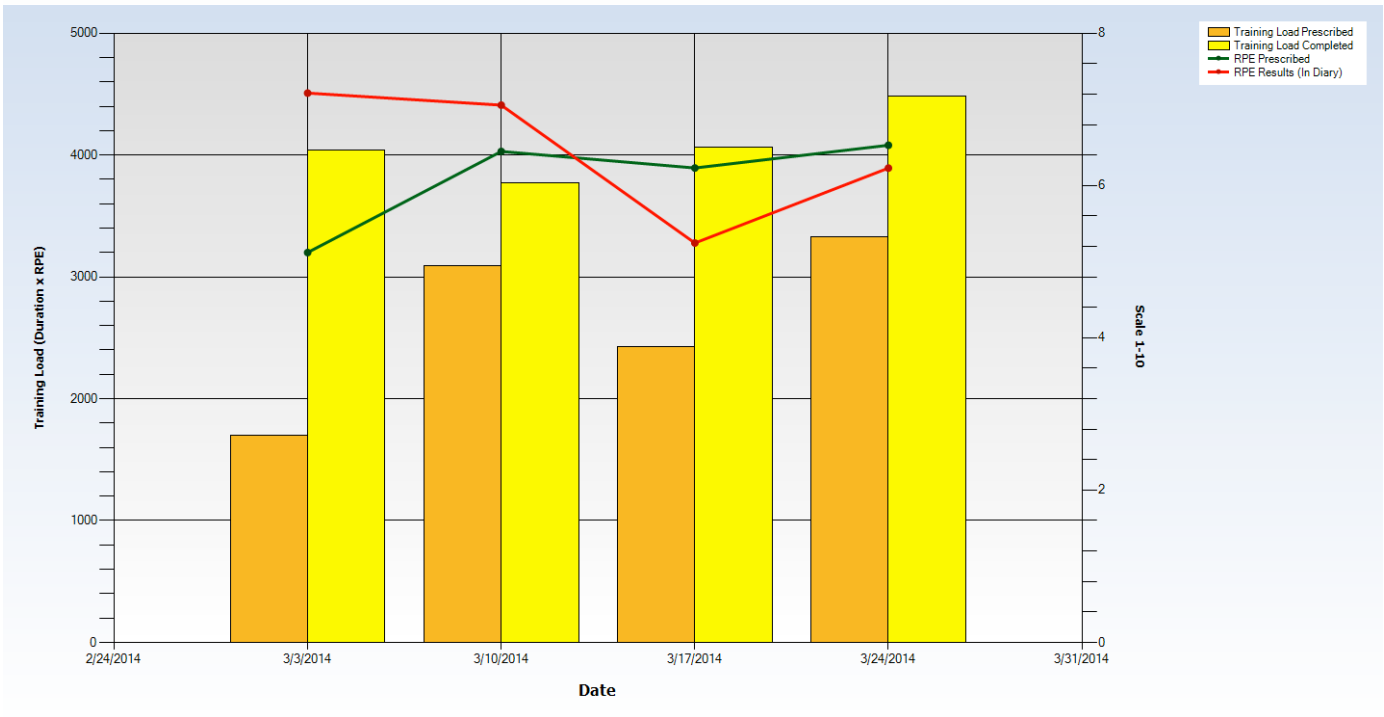
The simplest and most effective way to capture what the athlete actually did compared to the loads prescribed and the physiological response to the session is to do a training diary. The software systems we use have embedded training diaries, but you can also get inexpensive apps these days to monitor your athletes. Below is an example of the web-based training diary system we use in Visual Coaching Pro.



What types of analysis can you do?

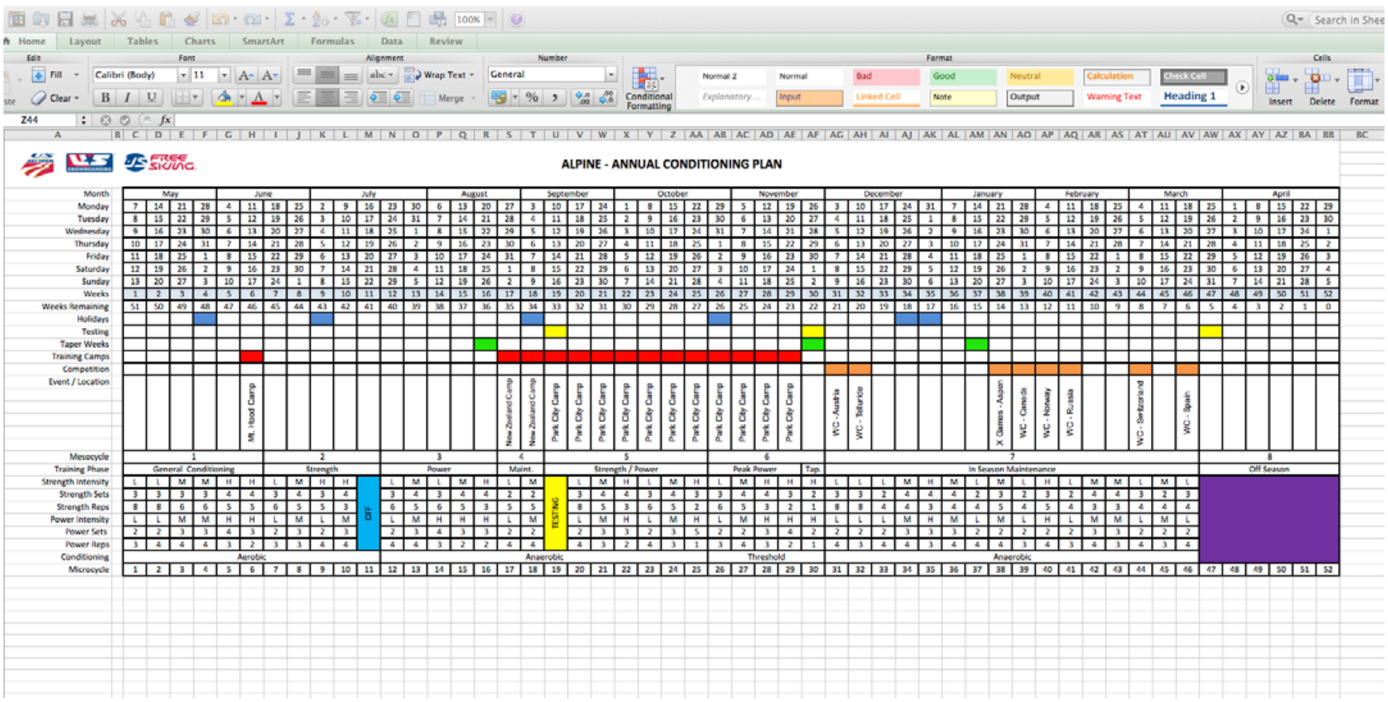
Visual Coaching Pro allows coaches to analyze an infinite number of training variables. The best way to approach program analysis is to have a question that needs to be answered. Having a question allows the coach to eliminate unnecessary variables that might be overwhelming. Below is a chart representing the repetition distribution during a hypertrophy phase of training. Here we simply see that a majority of the exercises have repetitions of eight. This makes sense, considering a hypertrophy phase includes high repetition exercises. The yellow chart shows the training load and RPE that was prescribed by the coach compared to the training load and RPE that was actually performed by the athlete. This chart gives coaches valuable insight on what the athlete is actually doing. In this example, we see the athlete performed a significantly greater load, than what was originally planned.

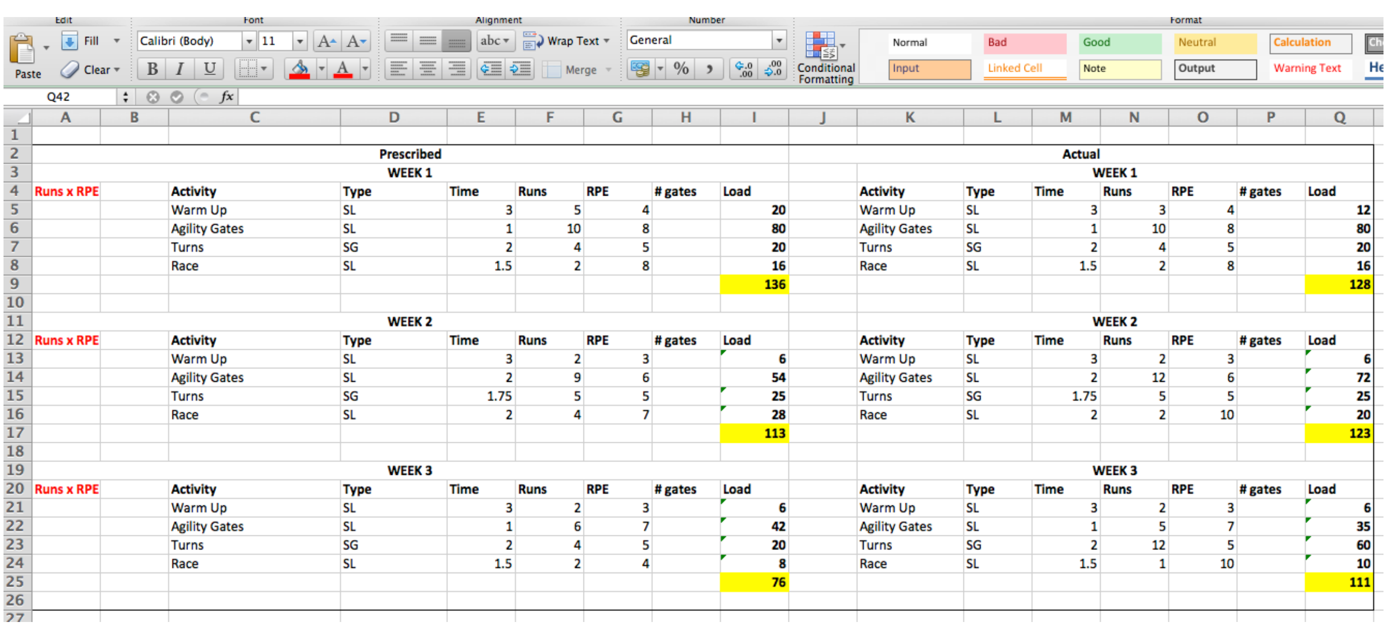




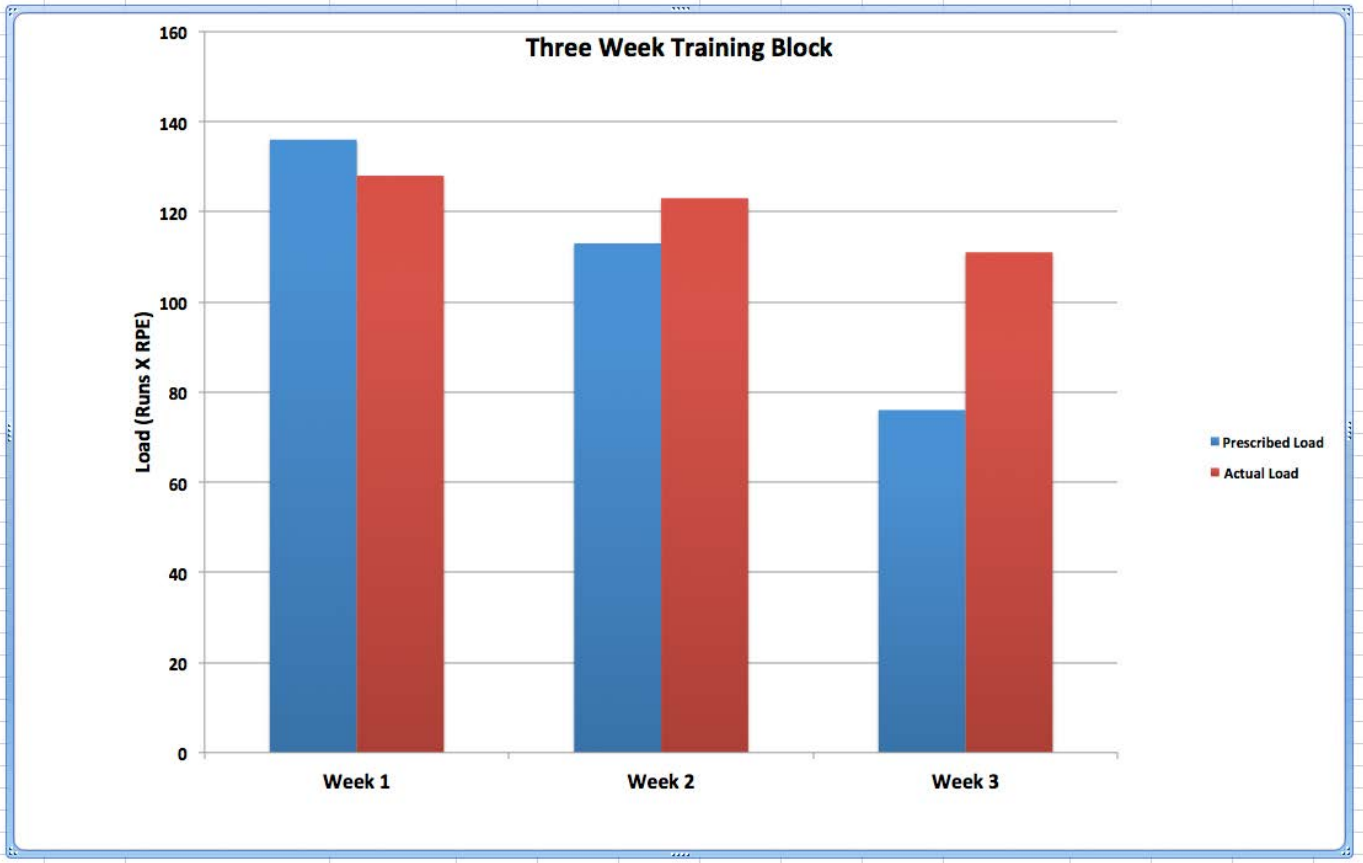
What's available to clubs?

Although Visual Coaching Pro and Athlete Management Platform are two very useful tools at the USSA, not everyone has the resources to access these programs. Microsoft Excel is a great tool that can be used to produce training plans, and also analyze programs. Excel has numerous features that can aid coaches in developing annual plans, designing training blocks, and also administering daily training sessions. With the implementation of simple functions, coaches can analyze training load in the gym, and on the hill. This information can then be used to better predict performance and also better prepare the athlete for the necessary demands of their sport. Once a coach tracks performance for several seasons, they can look at a bigger picture of an athlete's development. The most important message to remember is that if you are not measuring it, you are not managing it. Below are examples of using Excel for training software, and then using the recorded data to track on hill training load.





	Prescribed						Actual					
	WEEK 1						**WEEK 1**					
Runs x RPE	**Activity**	**Type**	**Time**	**Runs**	**RPE**	**# gates**	**Load**	**Activity**	**Type**	**Time**	**Runs**	**RPE**


Three Week Training Block
Load (Runs X RPE)
160
140
120
100
80
60
40
20
0
Week 1
Week 2
Week 3
Prescribed Load
Actual Load

Effects of Travel on Performance

Mike Bahn

Travelling away from home for training and competition is standard practice for most elite, club, and recreational athletes. Unfortunately, performance can be negatively affected by the distractions of a new environment, changes in schedule, disruption of a standard diet, and physiological stress and changes associated with travel. The well-informed coach will plan ahead by developing a food plan, attempting to minimize the effects of jet lag, and knowing how to deal with changes in altitude for living and training. A well-rehearsed plan with help athletes feel comfortable and keep everything similar to a usual daily routine for training and competition.

Planning Ahead for Travel

Traveling can often lead to a feeling of fatigue known as "jet lag," which is characterized by disruptions to the body's normal circadian rhythms. Jet lag occurs when the body's normal daily cycles of sleep, metabolism, temperature, alertness, and heart rate become confused between the place of departure and the place of arrival. Typical symptoms include disrupted sleep, changes in mood state, loss of appetite, upset stomach, and disorientation. Symptoms tend to be more pronounced and last longer when travelling Easterly rather than in a Westerly direction, and will also be influenced by the number of time zones crossed. Naturally, not all athletes will be affected in the same way, or to the same degree. Regaining normal sleep patterns will typically take 1 day for every time zone changed. It also appears that young people tend to cope with time-zone transitions better than older people do. Finally, the more experience you have with traveling usually results in better adaptation to the time zone changes. Prior to Departing you can adopt a positive mental attitude of travel, stay well-hydrated in the days leading up to departure, schedule easy exercise before leaving, and focus on high-quality sleep in the last 48 hours before you depart. During Travel, eat healthy snacks and meals, stay hydrated, and wear comfortable and loose-fitting clothing that also allow you to adjust layers as needed. Change your watch, phone, and habits to your destination time zone right away. Try to adopt similar meal and sleep patterns during travel that reflect the daily schedule of your destination. During long flights you should try to get up and walk around the cabin every couple of hours and perform simple stretching and mobility exercises in your seat or available space. After Arrival you should try to stay awake until at least 9:30 PM that night, get out and do some light exercise, and eat at the normal meal times of your destination. Realize that you will be tired for the first few days after arrival, regardless of how you felt when you left. You should plan ahead for this time of adjustment, scheduling light training in the first 2-3 days after long travel.

Major nutritional challenges faced by athletes while travelling can include: intake of adequate carbohydrates and protein, meeting daily vitamin/mineral requirements, maintaining adequate hydration, and controlling food safety. Coaches shoulder Plan Ahead to know where, when, and what his/her athletes are planning to eat, and what the daily schedule looks like. Find out if any special meals or food restrictions are required (vegetarian, gluten-free, etc.). Additionally, it helps to know what foods your athletes enjoy eating and the feasibility of providing that food at your destination. Research the Destination to know what foods are available, where and how grocery stores, restaurants, or catering can meet food demands, and what potential hygiene or food safety risks are present. Meals and Snacks should be pre-planned for during travel (plane or car), on the hill, and meal times. Additionally, long trips can lead to athlete boredom which can translate into extra snacking. Drinking water regularly and chewing sugar-free gym can decrease the temptation to snack. In-flight Fluid Ingestion is important to prevent becoming dehydrated because pressurized cabins cause increased fluid losses. Athletes should take their own supply of bottled water and/or sports drinks to supply both fluids and electrolytes. Food Safety measures at the destination can help prevent gastrointestinal issues such as cramping, diarrhea, constipation, or decreased desire to eat. Using bottled water for drinking and cleaning teeth, avoiding ice and tap water-washed salad and vegetables, and avoiding "high-risk" areas can be helpful. Adopting good personal hygiene and food safety practices will help to decrease the risk of infection and illness.

Being an athlete or coach in alpine skiing usually means living, training, and competing at high altitudes. Travel from sea level to altitude (usually 8,000+ ft) can negatively affect the body, and sometimes develop into cases of acute mountain

sickness. Symptoms can include: difficulty sleeping, headaches, dizziness or light-headedness, fatigue, and shortness of breath. Illness before travel can increase the risk for these symptoms. To minimize the deleterious effects of travel to high altitude, there are a number of measures you can take. You should attempt to acclimate to increasing altitudes gradually. Upon arrival at altitude, increase your fluid intake, including both water and sports drinks. To minimize fatigue, ensure proper nutrition and energy intake and allow for lighter training and rest days in the first few days of arriving. Individuals who have severe reactions to altitude travel should consult their doctor prior to departure.

Warm Up and Recovery for Alpine Skiing

Michael Naperalsky, MS, CSCS

Alpine skiing performance is the result of countless hours of ski-specific training. The time on-hill is greatly improved, however, with appropriate warm-up and recovery protocols. Dry-land training in the gym or ski training on-snow is enhanced by understanding that what happens before and after the session is incredibly important. Each training session begins with an active dynamic warm-up to prepare the body for exercise, and ends with recovery methods to allow for optimal re-fueling and adaptation. Essentially, the active dynamic warm-up signals the body that you are beginning an exercise bout. The warm-up has two primary goals: to improve performance and (hopefully) help reduce the incidence of injury. A well-designed active dynamic warm-up consists of three components: 1) light cardiovascular activity, 2) active mobility movements, and 3) dynamic speed movements. These activities will increase metabolism, initiate sweating, increase joint and muscle range-of-motion, and improve power outputs during exercise. Once a dry-land or ski session is completed, recovery methods help the body re-fuel energy stores, repair damaged tissue, and restore hormones to resting levels. Like the warm-up, an appropriate recovery protocol also consists of three components: 1) recovery snack within 30 minutes of exercise, 2) stretching or foam rolling to improve flexibility, and 3) rest and sleep to allow optimal adaptation to training. The best training stimulus in the world can fall short of its goals without an active dynamic warm-up and proper recovery from exercise.

The Science Behind Warm Up and Recovery

Active dynamic warm-ups prepare the body for physical work by increasing breathing and heart rate, creating greater ranges of motion throughout muscles and joints, increasing core body temperature, and increasing circulation to allow the delivery of oxygen and nutrients while increasing muscle temperature to improve elasticity (Woods, 2007). Every warm-up should begin with light cardiovascular exercise which will increase levels of activity, initiate sweating to regulate body temperature, and increase aerobic metabolism to fuel exercise. Active stretching involves fluid movements that move muscles and joints through progressively greater ranges of motion. Dynamic exercises act to "ramp up" your central nervous system, exciting your body to be quick or powerful. Active dynamic movements have been shown to be more effective than static stretching ("reach and hold") to improve strength outputs (Fowles, 2000) and power during jumping (Holt, 2008). For this reason, it is suggested that static stretching is not recommended before exercise.

Recovery from exercise helps the body return to homeostasis (resting) under controlled conditions. A light 5-10 minute Cool Down spin after intense activity will help the body's breathing and heart rate lower gradually and also help return venous blood to the heart. Eating a healthy mix of carbohydrate and protein (~ 40g Carb + 15g Pro) should occur within 30-60 minutes after exercise, the key window for re-fueling that allows for better synthesis of muscle glycogen (Ivy, 2002). Foam rolling and/or static stretching can also follow exercise. Stretching when muscles are already warm allows for greater ranges of motion and should help improve overall flexibility in the long-term. The final and most important method for total body recovery is sleep. During sleep the body reduces levels of stress hormones and increases secretion of growth hormone, which decreases sympathetic tone (stress), increases protein synthesis to help repair muscle tissue, and allows the brain to rest.

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Return to Ski and Snow Criteria and Protocols

Jennifer Kimball PT, DPT, OCS, SCS

Alpine skiing notoriously has a high injury rate particularly involving the anterior cruciate ligament. At the elite level within the USSA our injury rates over the last 3 seasons have been 20%. Other studies have found ACL injury rates to be 28% among elite Alpine athletes with a 19% reinjury rate. Establishing criteria that determine musculoskeletal readiness to return to sport with a logical progression into racing is imperative to minimize the risk of reinjury, and safely return athletes back to a competitive level.

Criteria and Progression at the Elite Level

Rehabilitation typically involves two phases with criteria for advancement. Initial rehabilitation begins with establishing the musculoskeletal readiness to return to snow (typically a 5-8 month process depending on the injury). Concomitant injuries such as meniscal tear, defects in the articular cartilage, tibial plateau fractures often occur with ACL injuries at the elite level, and will change how quickly rehabilitation can be progressed. Within the USSA measures of ROM, girth, isometric force production, dynamic functional symmetry, power, aerobic fitness, functional movement, as well as biologic healing times are used to determine musculoskeletal readiness to return to snow. Typically our athletes meet 92% or greater symmetry between surgical and non-surgical side, as well as 92% of preinjury testing for the above listed measures prior to returning to snow. Specific plyometric and agility progressions are completed and passed prior to return to snow. Once an athlete is allowed to return to snow, a gradual progression of ski specific skills is implemented while continuing a balance of time in the gym to maintain strength and power. The skiing is limited and supervised by someone in Sports Medicine, Sports Science or a coach. Progression into skiing is controlled by the number of days per week, number of runs per day, and the difficulty of the terrain. Finally after 2-3 months back on snow, meeting the above criteria, and with physician and coach recommendation/clearance an athlete is then returned to competition.

Recommendations for Progression at the Club Level

Require some form of functional testing prior to allowing athletes to return to snow. Find a physical therapist or athletic trainer in your area who is familiar with lower extremity functional testing for return to sport. Even without the equipment that may be available to those on the elite level, there are still well published and validated functional measures for return to sport. Functional performance measures that examine range of motion, strength, power, landing mechanics, proprioception and balance should be used. Examples of functional performance measures that can be used include hop testing, drop vertical jump landing force assessment, tuck jump assessment, Y balance test or BESS test, Functional Movement Screen, Modified Agility T-test, and Single Limb Average Peak Power Test over 10 seconds. One resource to find a provider that may be familiar with some of the testing http://www.apta.org/apta/findapt/index.aspx?navID=10737422525. Search for a Sports Clinical Specialist (SCS) or an Orthopedic Clinical Specialist (OCS).

Once the athlete has demonstrated good outcome and functional symmetry with performance measures they can progress to return to snow. The progression back into ski specific skills should be gradual, controlled, and supervised. Skill progression should proceed from easiest to more advanced skills, not progressing unless mastery of lesser skills has been achieved. Time on snow should be balanced with dry-land training to maintain strength and power. Progression onto snow should not be rushed, and may take 6-8 weeks prior to an athlete skiing competitively.

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Screening for Injury Prevention

Bob Poehling

Neuromuscular screening is a simple set of tools to help confirm the progress a sound strength and conditioning program can provide for an athlete. A long continuum has developed in the realm of neuromuscular screening, whether it falls under performance enhancement or injury prevention. In reality, it should cover a large array of the continuum. Screening will enhance the injury prevention modalities present in your strength and conditioning program, while also providing a suitable platform to build a stronger and more powerful athlete. The screening process should follow the same guidelines as the testing process, where the data collected is reliable, repeatable, and relevant.

Screening Guidelines

Movement screening is very similar in many ways to physical assessments, however they test very different characteristics. Physical assessments quantify the physiological capacity of specific energy systems, whereas movement screens assess the quality of specific movement patterns. Movement screens are not to be used as a diagnostic tool of current injuries as this should be left to a well-qualified professional. Instead, they should provide insight into ongoing effects of past injuries and the potential for future injuries specific to the sport.

Movement screens can incorporate numerous different technologies and resources. One can use a simple app on a cell phone or high-speed high-definition video analysis, or a simple wooden dowel or a digital handheld dynamometer. The most popular screen in the U.S. currently is likely the Functional Movement Screen. This provides a clear protocol with minimal equipment that nearly any coach can perform. However, there are alternative screens that provide their own unique advantages, such as the Movement Competence Screen, and all such alternatives must be considered. In the end, the process is the same: test-retest to confirm the progress of the program.

Once a suitable movement screen has been performed, a plan must be made to provide an intervention for any dysfunctions discovered. This should be done under the collaborative effort of a strength and conditioning coach and an athletic trainer or physical therapist providing an integrated treatment approach. This approach can then provide the athlete with a comprehensive strength and conditioning plan based upon movement screen results, which will produce the most effective results with a defined methodology.

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Recovery Nutrition

Allen Tran, MS, RD

Refueling after training is like putting money in the bank

- Glycogen is the body's safe deposit box for fuel for muscle tissue
- No food & fluid after exercise, the body is unable to completely recover → you're leaving gains on the training floor!

Post-training nutrition is particularly important for "busy athletes":

- Athletes who workout twice daily
- Athletes who compete in all-day, multiple-day, and/or in events with morning prelims followed by afternoon finals
- For these athletes, the recovery fuel also serves as "prep" fuel for the later exercise session
    - In these training situations, keep the food simple, higher in Carbs, low-moderate protein for faster absorption

Barriers and solutions to factors interfering with post-exercise fuelling

1. *Fatigue – interfering with ability/interest to obtain or eat food*
    - Solution: Have convenient options easily available to the athlete (packing recovery snacks, having shakes available, using shaker bottles to encourage fuelling right after training)
2. *Loss of appetite following high-intensity exercise*
    - Solution: Liquid options tend to be more palatable vs. solid food options, but experiment with athlete to see what foods they are more likely to want after training
3. *Limited access to (suitable) foods at exercise venue*
    - Solution: Be proactive and either provide or encourage athletes to carry a supply of good training snacks (with **both** Carbs and Protein) and fluid at training or on-hill.
4. *Other post-exercise commitments & priorities (coaches meetings, drug tests, cool-down activity)*
    - Solution: Build into schedule a time following training for rehydration and recovery fuelling. Convenience foods like pre-cut fruit, bars, and shakes can be consumed quickly

Examples of good recovery snacks

General rule: 35-60g Carbs / 15-20 g Protein

- Whole Food
    - Chocolate Milk
    - Greek Yogurt (with fruit)
    - Nuts with dried fruit (Trail mix!)
    - Almond/Peanut Butter sandwich
- Smoothies (can pre-make if access to blender is limited)
    - Basic recipe: ½ cup greek yogurt, 1 cup frozen/fresh berries, 1 small frozen banana, ½ cup water or ice, add a handful of spinach for a "green smoothie"
- Convenience foods
    - Energy bars (Clif Bar, ProBar) - if you choose granola bars (Nature Valley), add a protein source (string cheese, nuts, etc)
    - Protein Shakes (look for a 2:1 up to a 4:1 ratio of Carbs:Pro)

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