TRAINING AND PERIODIZATION FOR SNOWBOARD CROSS, PARALLEL SLALOM AND PARALLEL GIANT SLALOM

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ABSTRACT

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Snowboarding is a popular recreational sport, but it is also an elite sport. Snowboarding has been an Olympic sport since 1998. There will be five different snowboarding disciplines competed in Winter Olympics in Sochi 2014 (half-pipe, parallel giant slalom, parallel slalom, snowboard cross and slopestyle). Most of the snowboard cross and parallel event competitions are organized by International Ski Federation (FIS). FIS also organizes the World Cup and every second year Snowboard World Championships.

Snowboarding environment is challenging. Riders are frequently exposed to training in cold environments and at high altitudes. Because snowboarding is a technical sport snowboarders spend extensive time on-snow training. Apart from that elite snowboarders need to have a good physical fitness. Snowboarders experiences high ground reaction forces (McAlpine 2010). They also need to have good aerobic fitness, anaerobic capacity as well as good balance and power production capacity (Bakken et al. 2011; Bosco 1997; Creswell & Mitchell 2009; Neumayer et al. 2003; Platzer at al. 2009; Szmedra et al. 2001; Veicsteinas et al. 1984). Also, coaches have to pay attention to injury prevention because snowboarders, especially snowboard cross riders, have high risk of injuries (Flørenes et al. 2012). Annual training plan for snowboarders can be divided into transition, preparation and competition phases. Transition phase refers to time after competition season (competition phase) for athlete to recover physically and psychologically. Purpose of the preparation phase is to build up good fitness base for the competition season. Many kinds of strategies are used when planning training for an athlete. Linear and non-linear periodizations are both in use. It depends on the individual athlete what kind of training program should be planned. It is very important to individualize programs according athletes' needs.

Key words: snowboard cross, parallel slalom, parallel giant slalom, training, periodization

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1 INTRODUCTION

Snowboarding is a popular recreational sport. Apart from being a popular leisure sport it is also a competitive sport. Snowboarding became a Winter Olympic Sport in 1998. First competed events were half-pipe and giant slalom. Snowboard cross (SBX) was competed first time in Olympics in 2006. Winter Olympic Games in Sochi will include five snowboarding disciplines: half-pipe, parallel giant slalom (PGS), parallel slalom (PSL), snowboard cross and slopestyle. To be able to compete in a top level, athletes need high skill levels and physical fitness.

Snowboarding is a challenging sport. Training environment is cold and at times training altitude is very high (> 3000m). Other kinds of challenges provide the snow as an unstable surface and visibility, which can be sometimes only few meters. As a versatile sport athletes need to have good muscle strength, aerobic fitness, anaerobic capacity, balance as well as agility and speed. It can be challenging to plan training of all these parts of fitness, in addition to snowboard training on snow, and still have sufficiently time for recovery. Even though there is need for good physical fitness, the most important part of the training is skill training (snowboarding) on snow. There should be as much as possible on-snow training. In addition to on-snow training physical fitness training should be part of snowboard cross and parallel events (PGS and PSL) rider's training. For the majority of snowboarders it is not possible to train all year around on snow and therefore physical training is the most important training mode during summer.

The purpose of this paper is to cover the basic principles of elite snowboarders training for snowboard cross and parallel events. First, physical and physiological demands of snowboard cross and parallel events will be discussed and later focus will be on training and periodization of training. There is published research about snowboarding injuries, but apart from that published research about snowboarding is very limited (e.g. Torjussen & Bahr, 2006; Bakken et al. 2011). In order to cover the purpose of this paper results from skiing research are also applied (e.g. Berg & Eiken, 1999; Bosco, 1997).

2 OVERVIEW OF SNOWBOARD CROSS AND PARALLEL EVENTS

In this chapter competition system, riding technique and environmental issues will be discussed. Competition system part overviews the parallel event and snowboard cross competitions which are mainly held by FIS. Riding technique section concentrates mostly on carving technique. In environmental issues part effects of high altitude and cold exposure on performance will be reviewed.

2.1 Competition system

2.1.1 Parallel events

Alpine snowboarding events (PGS and PSL) are mainly held by organizations belonging to International Ski Federation (FIS). Competitions are categorized to 3 different levels: FIS competitions, Continental Cup competitions and World Cup competitions. Also national federations held competitions that are not official FIS competitions. During season 2012/2013 there will be 11 parallel snowboarding events in World Cup between December and end of March. FIS Snowboarding World Championships are held in every second year. Competition disciplines include both parallel slalom (PSL) and parallel giant slalom (PGS). Snowboarding has been a part of the Olympic Games since 1998 (Nagano). Competition program in Sochi 2014 includes both parallel events (parallel slalom for the first time). (FIS, 2012a.)

Picture 1. FIS Snowboard World Cup parallel slalom course in Moscow © Oliver Kraus (FIS, 2012b).

In World Cup competitions, parallel events include qualification and finals. Qualification consists of two runs in both courses, which are as similar as possible (picture 1). After first qualification run, only 16 best of each course advances to elimination round. Times from the qualification run 1 and run 2 will be added together. The top 16 athletes advance to the finals where riders race against their opponent (picture 2). In finals each pair of competitors has to make two runs. The competitors change courses for the second run. After these two runs the faster rider advances. Top 4 athletes have to make 10 runs during one competition. In parallel events it is recommended to set around 25 gates. Distance between gates is 10-14m in PSL and 20-27m in PGS. It takes approximately 35-45 seconds to complete PGS course and approximately 22-30 seconds to complete PSL course. (FIS, 2012a.)

Picture 2. FIS Snowboard World Cup parallel giant slalom course © Oliver Kraus (FIS, 2012b).

2.1.2 Snowboard cross

International Ski Federation also runs snowboard cross (SBX) competitions. Competitions are categorized in the same way as alpine events. Season 2012/2013 includes nine World Cup competitions and World Championships are held every second year. Snowboard cross became an Olympic sport in 2006. Organizations outside FIS also held snowboard cross (boardercross) competitions. One of these is highly respected annual sports event Winter X Games.

In FIS World Cup snowboard cross competitions have qualification and finals on separate days. Qualification includes two runs and the best time out of these two runs determines the qualification ranking. 48 men and 24 women advance to finals. In finals 6 riders compete simultaneously on same course (picture 3). Three fastest advance from round to round. On the qualification day all the riders will have two runs and on finals top 12 men will have 4 runs and top 12 women 3 runs. Snowboard cross course includes for example jumps, banks, drops and rolls. Duration of the snowboard cross course is around one minute. (FIS, 2012a.)

Picture 3. FIS Snowboard World Cup snowboard cross course © Oliver Kraus (FIS, 2012b).

2.2 Riding technique

There is unfortunately very little published research about riding technique in parallel events and SBX. For this reason the main focus of this section is on alpine skiing racing technique and SBX technique is covered only shortly at the end. Alpine skiing technique is very similar to technique used in PGS and PSL. Gurshman (2005) studied the technique of the best skiers in the world. Below are presented common features that the top skiers had in common.

Crossover and crossunder. Both of these movements are used in modern ski and in snowboarding. Crossover, refers to movement which the center of the mass crosses over the skis, is used mostly in giant slalom and in steep slopes. Crossunder, in which skis cross below the centre of the mass, is prevalently used in slalom and also on the flatter sections of the giant slalom course. Crossunder technique is usually combined with down-unweighting. In down-unweighting skier retracts his legs during transition phase (when changing edges) and extends them into the turn. Combination of crossunder and down-unweighting is used especially in shallow turns on moderate terrain. Another technique is double motion technique. There the rider's center of the mass is at highest position during transition phase. Rider bends his knees and is in the lowest position near the gate and starts then to extend legs again. This results in very high ground reaction forces just under the ski gate. Double motion results in non-optimal motion of the skier's mass center. To determine what kind of riding technique to use, the rider has to take into to account e.g. the steepness of the race course and snow conditions. (Gurshman, 2005; Supej et al. 2002.)

Early edge engagement and line of skiing. Skis/Snowboard needs to be on its edge early in the turn. When change of the edge has been done fast, the rider is able to accelerate before the fall-line. Shape of the turn is not a half circle, but rather like a long comma. Most of the direction change during a turn should be done above the fall-line, so that about 70% of a turn is completed before the gate. At the start of the turn there is some pressure on the front of the ski and turn usually finishes with the pressure on the tail. (Gurshman, 2005.) With snowboard this means that there is more pressure on the front leg at the beginning of the turn and more pressure at the back leg at the end of the turn. The shortest line is not always the fastest line. It might also be very hard to consistently keep the shortest line during the entire race course. Although it has been found, that skiers with shorter and straighter line had higher average velocities. It has to be noted that individual differences in this research were quite big and e.g. fastest rider had a longer line than the average. (Žvan & Lešnik, 2007.)

Pressure in the fall-line and gliding. Main issue in skiing/PGS/PSL is to create speed and maintain speed during turns. This is possible by loading the skis/board above and into the fall-line. Impact is greater in giant slalom, but this also enhances slalom performance. Top racers release the pressure coming out of the fall-line. To produce acceleration, combination of a cross movement, early edge set and pressure in the fall-line with early release, are used. (Gurshman, 2005.) In SBX there are parts where riders do not have to turn, but just ride straight forward. The fastest way is to avoid edging of skis/snowboard and ride skis/snowboard as flat as possible on the snow. Leaning forward or backward during gliding does not seem to affect gliding times. (Federolf et al. 2008.)

Beginning of the SBX course. A study from Vancouver Olympic Games 2010 skicross shows that the first part of the course is the critical part. The same kind of analysis has not been done with snowboarding, but the course was same for snowboarders and skiers. Authors found that 87.5% of riders, who were ranked 1st at the first turn, qualified from round to round. 81.25% of women and 56.25% of men, who were ranked 2nd at the first turn, qualified from round to round. Also, none of the men who were ranked 4th at the first turn qualified to next round. (Argüelles et al. 2011.) This highlight the importance of the start and technical skills required to perform the first obstacles as quickly as possible. First obstacles of the course are often very technical obstacles like Wu-Tangs, rollers or jumps.

2.3 Environmental issues

2.3.1 High altitude

Most of the snowboard races are held in low altitude (500-2000m), but some of the races (e.g. Telluride, US; Copper Mountain, US) are held in moderate altitude (2000-3000m) and some (e.g. Valle Nevado, CL) even in high altitude (>3000m) (FIS, 2012). During winter time training happens at low and moderate altitude, but especially during autumn on-snow training is executed on glaciers at high altitude. Atmospheric pressure declines as a function of increasing altitude. Reduced atmospheric pressure causes a reduction in the inspired partial pressure of oxygen (P_{O2}). Changes in the pressure also affect air density. Reduction in atmospheric pressure has physical and physiological effects that may have strong impact on sport performance. Training at high altitude can affect 1) oxygen delivery to and oxygen uptake by the working muscles during exercise and recovery, 2) on air resistance, lift and drag and 3) the process of acclimatization. That can affect acid-base balance and oxygen transport over a longer period of time, as well as movement timing and motor skill proficiency. (Chapman et al. 2010.)

Athletes should allow time for acclimatization especially in endurance sports. It takes 1-2 weeks for acclimatization in moderate altitudes. (Chapman et al. 2010.) Too fast ascent to high altitude may cause acute mountain sickness. Symptoms of acute mountain sickness are e.g. headache, nausea, weakness and dizziness. Acute mountain sickness is unusual at altitudes below 2500m. Athletes who experience acute mountain sickness should stop ascending and rest at the same altitude. Symptoms usually disappear at the same altitude in 24-48 hours. (Barry & Pollard, 2003.) Sufficient energy and water intake is also important when training and staying at high altitude. Energy intake should meet requirements of raised energy expenditure. Water requirement at high altitude theoretically increases due to increased insensible water loss at low ambient water vapor pressure. However, studies have not been able to prove this unanimously. (Westerterp, 2001.)

Alpine skiing training at high altitude (~3000m) for six days has a positive impact on anaerobic capacity. Anaerobic capacity was assessed with 30s Wingate anaerobic test. No dramatic effects in homeostasis of athletes were found, but there was a clear improvement on performance. (Elegańczyk-Kot et al. 2011.) It is recommended that winter sport athletes with a skill component would have a sufficient acclimatization period to allow adequate adjustments in motor skills and movement timing. Due to a reduced air density environment, it may require a significant number of repetitions to make the appropriate motor skill adjustments necessary for competitive success. Though there is not enough available research to guide specific recommendations. (Chapman et al. 2010.) Chapman et al. (2010) give five recommendations for winter sport athletes planning competitions at altitude: 1) allow extra time and practice for athletes to adjust to the changes in projectile motion (lift and drag); 2) allow time for acclimatization for endurance sports: 3–5 days if possible for low altitude (500–2000 m); 1–2 weeks for moderate altitude (2000–3000 m); and at least 2 weeks if possible for high altitude (>3000 m); 3) increase exercise-recovery ratios as much as possible with 1:3 ratio probably optimal; 4) consider the use of supplemental O_2 in between heats (Alpine skiing) to facilitate recovery; 5) for competitions at sea level, the 'live high–train low' model of altitude training can help athletes in endurance events to maximize performance.

2.3.2 Cold exposure

Snowboard training and competitions are held in cold environments. Air temperature can be even below -20 degrees. The international Olympic Committee recommends that

“Competitions should be avoided when competitors would be exposed to combinations of air temperature and wind speed (including the speed of the competitor) that achieve an effective windchill temperature colder than − 27°C “. That would mean e.g. air temperature -15 degrees Celsius with a competitor speed 40km/h. (Bergeron et al. 2012.) Although in that particular situation competitor is exposed to a -27°C only during competition runs. Athletes try to avoid getting cold by wearing more clothing. During competition this might be problematic, because it is important to minimize air drag. Competition clothing might be insufficient to keep athletes warm during competition. Athletes might have to wait long times between runs, it is important to have additional clothing after competition run to prevent heat loss. The principal external factors that facilitate heat loss are: cold temperature, wind chill (speed of competitor) and moisture in the air. To prevent heat loss vasoconstriction of peripheral blood vessels happens. In addition, there is an increase in skeletal muscle tone which increases metabolic heat production. Vasoconstriction could possibly impair performance by decreasing blood flow, which can lead to a reduction in oxygen delivery. (Nimmo, 2004.) Glycogen is an important energy source in alpine skiing and also probably in snowboarding (discussed in more detail later). It has been shown that suboptimal muscle temperature leads to a decreased high-intensity performance (Nimmo, 2004). Blomstrand & Essén-Gustavsson (1987) found that during intensive dynamic exercise at reduced muscle temperature there is a higher degree of glycolysis from glycogen compared with a muscle in normal situation. This can lead to an even higher degree of muscle glycogen depletion compared with training at normal muscle temperatures. In some subjects they also found more rapid lactate accumulation in cold muscle.

3 PHYSICAL AND PHYSIOLOGICAL DEMANDS OF ALPINE SNOWBOARDING AND SNOWBOARD CROSS

Only a limited amount of research about physical and physiological factors in alpine snowboarding and snowboard cross has been published to date. Due to the similar nature and duration of alpine skiing and alpine snowboarding/snowboard cross, research from skiing is also presented in this section to generate improved understanding about physical and physiological demands of a sport very similar to snowboarding.

3.1 Muscular strength

Berg & Eiken (1999) analyzed kinematics of world class alpine skiers in their competitive events. They found out that the range of the angle of the main load-bearing knee was greater in giant slalom (GS) (86-114 º) than in slalom (SL) event (98-111º). Knee-angles in Super-G were 83-96 º and in freestyle mogul skiing 62-133 º. (Berg & Eiken, 1999.) Around the same kind of knee-angles might be seen in parallel events also. Minimum angles are probably bigger in PSL than in PGS. In snowboard cross there is probably bigger range in knee-angles than in parallel events, because of rollers and jumps. Movement velocities are fairly slow in alpine skiing compared with other sports. Knee-angle velocity of the outside leg averaged $34 \pm 2°\cdot s^{-1}$ in GS, and $69 \pm 11°\cdot s^{-1}$ in SL. In freestyle moguls angular velocities exceeded $300°\cdot s^{-1}$.(Berg & Eiken, 1999.) Angular velocities in alpine snowboarding are probably also relatively slow like in alpine skiing. In snowboard cross there are phases where angular velocities are very slow (riding banks) and other phases (riding rollers) where angular velocities are higher. PSL and PGS are more rhythmic disciplines compared with snowboard cross. Berg & Eiken (1999) also demonstrated that alpine skiing events are characterized by a marked predominance of eccentric over concentric muscle actions both in terms of relative intensity and duration. Also muscle activation measured with EMG reached near maximal levels in almost every turn. (Berg & Eiken, 1999.) Front and back legs don’t share same pattern of muscle activation while snowboarding with the up-unweighting technique. During frontside turn with slalom board and freestyle board activation of rectus femoris and vastus lateralis muscles is higher in the rear leg. At backside turn with slalom board activation of rectus femoris and vastus lateralis muscles is lower in the back leg compared with front leg. Differences on a backside turn with freestyle board are less clear. There are also differences with muscle activation between the boards. Front leg has more activation while riding a slalom board, but with the rear leg trend seems to be the opposite. (Delecluse et al. 2001.)

According to Müller et al.(2000) maximum force on the outside leg in skiing is 2.5 times body weight and 1.5 times body weight on the inside leg. Similar kind of ground reaction forces (GRF) has been found in alpine snowboard carving. Bally & Taverney (1996) (according to McAlpine, 2010) found GRF around 2.5 times body weight during carving turn. Ground reaction forces can be even higher, because there were no available data about the skill level of the test subjects and equipment has changed a lot since 1996. Later study with highly skilled snowboarders (75kg) on hard packed snow found loads as high as 2750N (Knünz et al. 2001). In snowboard cross rider experiences higher forces, because of jump landings. McAlpine (2010) showed that during jump landings GRF can be over 4 times body weight.

Even though forces needed for alpine skiing are high, a recent study did not find correlations between muscle strength and racing performance (Neumayr et al. 2003). But vertical jump high has been reported to be a best indicator of a skier's performance (White & Johnson, 1991). Platzer et al. (2009) compared certain physical characteristics and performance among elite snowboarders. They did not find any significant correlations between muscular strength/power and performance with men riding SBX or parallel events. On the contrary, leg power and bicycle ergometer tests correlated with performance in women's parallel events. For women riding SBX tests that correlated with performance were: bicycle ergometer, leg power, core power, stability, bench press and maximum push off speed.

3.2 Anaerobic capacity

It has been concluded that ski racing involves around 55-65% energy contribution from the anaerobic system (Saibene et al. 1985; Veicsteinas et al. 1984). It takes 1-2 minutes for a single run in slalom or giant slalom. Run durations in parallel events are shorter (22-30s for PSL and 35-45 for PGS), but equal with snowboard cross (around 1min.). Shorter duration of parallel events could make it possible to perform at greater intensities. That can possibly lead to increased contribution of the anaerobic system. More research has to be made to find out contribution of anaerobic/aerobic system in snowboarding. Different levels of energy demands have been reported for alpine skiing. Tesch et al. (1978) observed energy demands equivalent to~80–90% $\dot{V}_{O2}$ max during downhill skiing, whereas Saibene et al. (1985) reported energy demands equivalent to 120% $\dot{V}_{O2}$ max during GS skiing. Veicsteinas et al. (1984) observed much higher demands equivalent to 160–200% V_{O2} max during SL and GS events. (Ferguson 2009.) Varying lactate levels after alpine skiing run has been observed. Tomazin et al. (2008) measured blood lactate level of 7.1mmol/l after 45s slalom course. Other studies have reported lactate levels following race from 9 to 13 mmol/l and from 5 to 26 mmol x kg-1 wet muscle (Andersen & Montgomery, 1988; Tesch et al. 1978).

High lactate levels are caused partly by vascular occlusion during sustained isometric contractions in ski racing. There is a restricted blood flow to working muscles (vastus lateralis) during ski racing. A greater reduction in blood volume and greater oxygen desaturation was observed during GS compared with SL. That is probably due to a more static and lower posture in GS. Relatively dynamic action in SL may allow better perfusion on the working muscles. Still, the rhythmic and alternating pattern of muscle contraction during the GS and SL appears to be an insufficient time to adequately reperfuse working muscle. (Szmedra et al. 2001.) Similar trend can possibly be found in parallel events. PSL is more dynamic and may allow more perfusion to working muscles compared with PGS. In snowboard cross there are parts where isometric forces are held longer than is PGS and also short rhythmic movements.

3.3 Aerobic capacity

There is contradictory evidence about the influence of aerobic power for ski racing. Some claim aerobic fitness has little importance on ski racing success while some claim that aerobic fitness is crucial on skiing performance. (Neumayr et al. 2003; Turnbull et al. 2009.) Platzer et al. (2009) found that maximal bicycle ergometer test correlated with performance with female snowboarders, but not with male snowboarders. Maximal V_{O2} -values for elite male skiers has been reported to vary between 52 to 67 ml/kg/min (Andersen & Montgomery 1988; Neumayr et al. 2003; Veicsteinas et al. 1984). Most of the summer/autumn training happens in glaciers. Training sessions can last even four hours. It is necessary to have good aerobic fitness in order to be able to have a good training session. Neumayer et al. (2003) suggest that high aerobic capacity is essential for several reasons; 1) to meet the energy demands of training and competition 2) to provide fast and sufficient recovery in short intervals between the runs and races 3) to sustain the overall stress of a long season.

3.4 Balance

Balance is the process in which the body's center of gravity (COG) is maintained vertically over the base of support. It relies on coordinated activities of multiple sensory, motor and biomechanical components. (Nasher, 1993, 261.) Research about the relationship between balance ability and snowboarding performance is very limited. It has been analyzed that many of the incidences in snowboard cross are due to a loss of balance (Bakken et al. 2011). The relationship between balance ability and injury risk has been established in many studies (Hrysomallis, 2011). It is possible that good balance abilities may prevent injuries in snowboarding. More research has been conducted in alpine skiing. Here results from skiing research are also summarized, due to a similar nature of snowboarding and alpine skiing.

It can be assumed that snowboarding performance benefits from enhanced balance. Snowboarding involves unpredictable perturbations in balance, because of unstable and unpredictable surfaces. No relationship was found between balance ability and performance measures with elite snowboarders. To test stability one-legged static balance test was used. (Platzer et al. 2009.) Static balance test might be inappropriate for snowboarders, because in snowboarding it is more essential to perform a task while maintaining or regaining a stable position (dynamic balance) than to maintain a base of support with minimal movement (static balance). On the contrary, Creswell & Mitchell (2009) researched skiers and found that dynamic balance (proprioceptive) ability increases with skill level. It is important to find what kind of balance test correlates best with snowboarding skills. In alpine skiing, lateral tilts -test on the balance board correlates with skiing skill test. Those who scored better results on lateral tilts test also got better results on skiing test. (Ružic et al., 2008.) Even though there is very little scientific research about the importance of balance in snowboarding it seems obvious that application of balance training program could improve body control and proprioception in snowboarders and further improve performance.

3.5 Injuries

Risk of injuries is high among elite snowboarding. Flørenes et al. (2012) interviewed World Cup snowboarders and reported 6.3 injuries per 1000 days of snowboarding. 37.8% of riders had time-loss injuries during competition season and 13.8% of riders experienced severe injuries(>28 days absence). Most of the injuries occurred during training on snow outside FIS events (28.3%), during World Cup or World Championships (27%) or during official training of World Cup or World Championships (17.3%). Five mostly injured body parts were knee (18.9%), shoulder/clavicle (13.3%), head/face (12.9%), lower back/pelvis/sacrum (10.3%) and ankle (9.4%). Torjussen & Bahr (2006) reported incidences for the different disciplines. They found out that snowboard cross riders had 6.1 incidences per 1000 runs and giant slalom riders only 1.9 incidences per 1000 runs. Knee, back and head were most frequently injured body parts. On their other study Torjussen & Bahr (2006) reported also overuse injuries. Knee (31%), back (18%) and lower leg (18%) were the body parts that suffered most of overuse injuries.

More detailed analysis has been made about the mechanisms of injuries in snowboard cross. Bakken et al. (2011) made video analysis of 19 injuries during snowboard cross

World Cup. Most of the injuries (13/19) occurred at jumps, 5/19 occurred while turning in banks and 1/19 while riding on rollers. In most of the cases (13/19) rider had already lost balance before the time of injury. In 3 cases injury happened due to a contact with another rider. Jumping-related injuries were caused by individual technical error (9 cases, losing control, catching the edge, incorrect damping at take-off, or timing of jumps), by contact with another rider (2 cases), by an inappropriate course line at take-off (1 case) or by excessively speed at take-off (1 case).

4 PSYCHOLOGICAL FACTORS

Snowboarders are known for their laid back attitude and emphasizing the importance of having fun while training and competing. Even though snowboarding is an individual sport most of the time on snow -training happens in groups. To be able to enjoy training in groups, coaches have to pay attention also to group dynamics. At times athletes from other sports are amazed of the group spirit that snowboarders have. Sometimes this good group spirit and having fun while training and competing can be interpreted as a lack of ambition or a lack of goal setting. From my own experience, I could say this is not the truth for the most of the parallel events and snowboard cross riders. Instead, even though the riders have a good group spirit, they are also individually competitive. A study conducted by Tyka et al. (2009) in the season prior to the 2006 Olympics in Turin is also contradictory with this interpretation. Most of the interviewed snowboarders wanted to have good results in competitions, participate in the Olympics or to be a professional. Also training schedules were obeyed well. Even with the high goals for the career 90% of snowboarders said that fun or pleasure is one of their motives for practicing snowboard. Other important motives were specific snowboard atmosphere, keeping fit and money benefits.

During SBX, PGS or PSL competition athlete has to first compete in qualification and then in several heats in the finals. After qualification runs the fastest advance to finals. Athletes have to compete against time in the qualification. In finals time does not matter, the athlete only has to beat his opponents. This might distract the athlete’s concentration. Both kinds of competition conditions should be practiced at training. In snowboard cross stress from other riders riding closely may cause the athlete to lose his concentration and this might lead to risk taking or errors (Bakken et al. 2011). Athletes also have to cope with fear of injuries, especially in sports like snowboard cross where injury risk is high. There are a lot of psychological factors that have to be taken into account during competition, but there are also factors during preparation or after competition that affect the athlete. Gordin & Henschen (2012) listed problem areas that USA ski and snowboard team encountered before and during games: non-selection to the team, injury, burnout, living arrangements, handling the media, dealing with the weather and other potential distractions, luge problems, and moving on after the games. Elite snowboarders travel long periods of time during a season. Long season and staying away from home for long periods causes challenges to athletes. Strategies to avoid burnout during long season can help athletes to cope with the long season and maintain their performance level.

5 ELITE SNOWBOARDERS TRAINING FOR SBX, PGS AND PSL

The most important part of snowboarders training is naturally on-snow training. On-snow training enhances the rider's technical skills, but is also beneficial for overall fitness. Physical fitness training is an essential part of the rider's summer training. In this section focus is on offseason physical fitness training.

5.1 Aerobic fitness

There is contradictory evidence of how much aerobic fitness correlates with skiing (also snowboarding) performance (Neumayr et al. 2003; Turnbull et al. 2009). But still, good aerobic fitness is required to complete training sessions at glaciers. It is suggested that aerobic fitness enhances recovery from high intensity intermittent exercise. It appears that there is a relationship between aerobic fitness and phosphocreatine (PCr) recovery after both submaximal work and repeated bouts of moderate intensity exercise. Recovery of PCr has been linked to fast power recovery in repeated efforts. Maximal oxygen consumption (VO_{2max}) is a widely accepted measure of aerobic fitness. During high intensity performance VO_{2max} /aerobic fitness does not always correlate well with PCr resynthesis. Although, it has been noticed that when exercise involves large muscle mass, the relationship between VO_{2max} and PCr resynthesis is quite strong. There is also evidence that increased aerobic fitness improves lactate removal. (Tomlin & Wenger, 2001.) SBX and alpine snowboard racers should also include aerobic training on their training plan.

Aerobic endurance training is subdivided in different categories. How it is subdivided depends on the author of the book or article. Here subdivision is made in the way that Mero et al. (1997, p. 183) presents it. Aerobic endurance training can be subdivided into a three categories: 1) low-intensity 2) moderate-intensity and 3) high-intensity (maximal endurance) training. Low-intensity endurance training is a base needed for building up good maximal endurance. When the base is good, athlete can put the focus on more intense endurance exercise. Low-intensity endurance exercise is 30-240 min long with intensity 40-70 % VO_{2max} (~ <150 heart beats per min (HR)). Low-intensity exercise affects on aerobic metabolism. Moderate-intensity exercise can be either continuous or interval training. One running bout is 10-20 min long with intensity 65-90% VO_{2max} (~150-170 HR). Total duration of the training is recommended to be 20-60 min with 1-2 min recovery between bouts. Moderate-intensity exercise also affects aerobic metabolism, but uses more carbohydrate as an energy source during training. Also lactate levels are higher. High-intensity endurance training is usually done by interval training. One interval lasts 3-10 min with recovery 1-5 min between bouts. Overall duration of the exercise is 5-30 min. It is recommended that 1-6 moderate- and high-intensity bouts should be included to a training session. (Mero et al. 1997, p.182-190.)

What type of endurance training a snowboarder should do depends on his training status. If aerobic fitness level is not very good more low-intensity exercises should be included to the training program. But it has been shown that high-intensity endurance exercise (near-maximal-intensity) ~95% HR_{max} is significantly more effective for improving VO_{2max} (Gormley et al. 2008; Helgerud et al. 2007.) It can be concluded that high-intensity endurance training should also be a part of the snowboarders training program. Including interval type of endurance training into the training program supports the interval-type nature of snowboarding. Training can be done during summer e.g. by inline-skating, cycling, motocross, horse riding, ball games. Heart rate should be monitored to find out the intensity of the training. Although aerobic training should be part of snowboarders training program, emphasis should be exercising power and strength.

5.2 Anaerobic training (speed endurance)

As mentioned earlier that PGS race run takes around 35-45 seconds, PSL run around 22-30 seconds and SBX run around one minute. Studies show that during an alpine skiing run, approximately 60% of energy comes from anaerobic system. Alpine skiing is characterized by repeated high force isometric and eccentric contractions which are characterized by ischemic nature. This will lead to an accumulation of metabolic by-products that will impact on the muscle’s force-generating properties. (Ferguson, 2009.) Snowboard cross and alpine snowboarding likely involves same kind of muscle contraction. Speed endurance tested with continuous jumps has been shown to be important physical capacity for skiers (Bosco, 1997). Purpose of the speed endurance training can be for example to enhance lactate removal, economy of anaerobic system, buffering system, anaerobic power, power endurance or alactic capacity (Mero et al. 1997). Due to the specificity principle of training, it would be best to execute speed endurance training on snow with snowboard. Because this is not possible offseason, snowboarders should try to use an exercise which is as similar as possible to snowboarding performance; for example continuous squat jumps. Squat jumps can be performed with extra weights or at uneven surface to stimulate muscles responsible of postural control.

Training intensities are above VO_{2max} in anaerobic training. One part of anaerobic training is speed training, which is discussed later. Other part of anaerobic training is speed endurance, which is divided into production and maintenance training. In anaerobic training the primary aim is to stimulate anaerobic energy production. Speed endurance training stresses both anaerobic and aerobic energy pathways. During exercise glycolysis progressively decreases and aerobic energy production increases. In “production training” exercise intensity is almost maximal. Production training exercise last 10-40s and rest periods of 1-5 min (> 5 times the exercise time) may be optimal. In “maintenance training” exercise periods are longer 5-90s and recovery is shorter (1-3 fold the exercise duration). The type of training depends upon the type of improvements wanted. “Production training” is effective in improving performance during very intense short-duration and repeated high-intensity exercises. “Maintenance training” is beneficial for improving the ability to sustain exercise at high intensity. (Iaia & Bangsbo, 2010.) Both “production training” and “maintenance training” may be beneficial for SBX and parallel event riders. An example of “production training” for snowboarders could be following: 8-12 times 15s of continuous squat jumping as fast as possible with extra weight (e.g. 20% max) with recovery 1,5-2 min performed twice a week.

Power endurance tests (continuous jump tests) have been used to evaluate skier’s anaerobic capacities. Those tests have been shown to correlate well with skiing performance (Bosco, 1997). Practical experience from Austrian women’s ski racing team shows that when emphasis of training shifted from strength endurance to maximal strength and power, improved values in power endurance test was shown. (Patterson et al. 2010.)

5.3 Muscle strength

Snowboarders have to work against strong ground reaction forces (McAlpine, 2010). This sets high requirements for snowboarders force levels. Skiing studies show that alpine skiing racing is markedly dominated by eccentric muscle work, due to a continuous vertical drop. Studies also show low angular velocities for the knee joint. (Berg & Eiken, 1999.) These factors have to be taken into account when planning a strength training program for a snowboarder.

The training program has to be designed to meet the individual snowboarders training goals. It is important to evaluate the athlete's fitness level and build up training program suitable for their current situation. It has to be avoided to place too much stress on the athlete before it can be tolerated. Strength training programs have to plan in a way that allows adequate recovery for the athlete. Successful recovery is an important factor in optimal performance. The specificity principle is important to remember when planning a training program for an athlete. In strength training this means that "Adaptations by the neuromuscular system and thus improvements in performance are specific to the exact type of resistance training performed". This applies to 1) muscle groups involved in the exercise, 2) movement pattern, 3) joint ranges of movement, 4) velocity of contraction and 5) type of muscle action. (Kraemer & Häkkinen, 2002. p.12-18) It is important to plan strength training program that involves same muscles as competitive snowboarding in a similar manner.

Strength training program can be targeted to improve, *hypertrophy of muscles, maximal strength, power or strength endurance* (Kraemer & Häkkinen, 2002 p. 21-35). *Strength endurance training* with high repetitions (>15) and multiple sets (3-6) may be most beneficial for core musculature in a sport like snowboarding. *Hypertrophic strength training* is targeted to cause hypertrophy (=increase in a muscle mass) in muscle. A requirement for training-induced hypertrophy is muscle's high tension for a sufficient duration. Studies have shown that ultimate degree of hypertrophy is achieved by using heavy loads (60-80% 1 repetition maximum (RM)), with multiple repetitions (6-12), short recovery (30-60s) and 3-5 sets. In maximal strength training intensity should be kept very high or maximal (80-100% of 1RM), repetitions are recommended as 1-5, rest between sets should be longer than in hypertrophic training (2-5 min) and 3-5 sets are recommended. The main purpose of the *maximal strength training* is not to induce changes is muscle size, but to increase muscle's maximal force. This type of training can lead to increase in the maximal force per cross-sectional area of the muscle. The main aim of *explosive strength training* is to improve muscle's capacity to produce explosive force and power. Typical loads are 0-60% of 1 RM. Usually loads around 30% of 1 RM are used to improve power abilities. Number of repetitions is relatively low 1-5, rest period 2-5 min and number of sets is 3-5. (Kraemer & Häkkinen, 2002. p. 27-35,58,72) Another type of training to improve leg muscle power is plyometric training. Plyometric exercises may have a vital role in augmenting the primary exercise's effectiveness and progress. Plyometric training utilizes stretch-shortening cycle (SSC). In SSC eccentric contraction is followed immediately by a rapid and powerful concentric contraction. Lower body plyometric training types are e.g. drop jumps, countermovement jumps, alternate-leg bounding, hopping. (Kraemer & Häkkinen, 2002. p. 39; Markovic, 2007.) All of these types of strength training are probably useful for a snowboarder. In chapter 6 (training periodization), it is discussed in more detail how different types of strength training could be included into a training program.

As previously mentioned, eccentric type of muscle work is dominant in alpine skiing, it can be recommended that snowboarders should include eccentric types of strength training exercises to their training program. Also isometric type of muscle work has been shown to have an important role in alpine skiing. Eccentric exercise can be for example Olympic squats 110% of 1RM with assistance during concentric work or jumps down box or stairs. In case of using jumping down stairs or from a box, extra weights can be used and height between start and landing needs to be large enough.

5.4 Balance

Good balance can reduce injury risk. Additionally, good dynamic balance is needed to perform muscle contractions while snowboarding if unexpected perturbations happen. Snowboarding is an open skill sport in which large forces are produced under unstable environmental conditions. Snowboarders and alpine skiers use slacklining as balance training which has been shown to improve dynamic balance (Keller et al. 2012). It is however uncertain if load intensities in slacklining provide an adequate stimulus for the stabilizing muscles needed in alpine skiing/snowboarding. Improving the strength of stabilizing muscles may be beneficial for injury prevention and an improved transfer of strength training effects in addition to the benefits for stability. It is recommended that strength training on unstable surfaces should be used in addition to traditional strength training programs. (Kibele & Behm, 2010.) This type of training can be e.g. Olympic squats, vertical jumps or one-leg squats on a wobble board or Bosu® ball. Trunk stabilization exercises can be done e.g. over a Bosu® ball or a Swiss ball. In addition to strength training on unstable surfaces like slacklining, suspension training or balancing on Swiss ball is also good ways to improve balance.

5.5 Speed and agility

Studies show that angular velocities of knee joint are fairly slow in SL and GS. Then again much higher knee angular velocities are seen in freestyle mogul skiing. (Berg & Eiken, 1999.) Angular velocities are probably slow in parallel events and faster angular velocities could be expected in some parts of snowboard cross course. This does not mean that there is no need for training speed or agility. Snow is an uneven and unpredictable surface. Snowboarders often need to correct their posture due to perturbations. As mentioned earlier, balance training improves postural control, but speed of corrections is also critical to determine how the following turn or obstacle will be performed.

Speed training should start at an early age. Too much aerobic endurance training at an early age may impair speed and power abilities of junior alpine skiers. (Patterson et al. 2010.) Speed can be divided in to three categories:1) reaction speed 2) explosive speed and 3) movement speed (Mero et al. 1997). Reaction speed and explosive speed is needed at the start of snowboard cross. This is an important part that should be included in training program of a snowboard cross rider. Parallel event riders also need explosive speed at the start. Agility drills are usually part of the snowboarders training program. Drills can be either “closed skills” or “open skills” drills. In closed-skill movements athletes know exactly what to expect. Open skills are required in order to react to an outside stimulus perceived by the sensory input system. (Foran, 2001 p. 154-155.) Outside stimulus can be for example an uneven surface, change of direction from signal.

5.6 Flexibility

SBX, PSL or PGS riding does not require extreme range of motions (ROM) of joints. Stretching increases range of motion about the joint. Increased ROM is said to be due to changes in musculotendinous unit. Some studies have suggested that stretching leads to improved performance and that is due to enhanced ability to stretch during a sport as well as decreased resistance of a less stiff muscle. However, there are numerous studies showing no improvement or reduced performance after stretching. There are a lot of variables in these studies which makes it difficult to compare them with each other. It is also hard to draw conclusions on how stretching would affect on snowboarding performance. Stretching has been also said to prevent injuries. Evidence about this is contradictory too. Most of the recent researches show that long static stretch just prior to performance decreases force/power production. Then again, dynamic stretches with activity of long duration seem to enhance performance. Even though there are probably no benefits for snowboarders to do long static stretches before performance, there are still health-related benefits associated with flexibility. It is recommended that all individuals should include static stretching in their overall fitness activities, because of health and functional benefits associated with increased ROM and musculotendinous compliance. (Behm & Chaouachi, 2011.) Snowboarding is a very asymmetric sport. Snowboarders should make sure that flexibility is equal in both limbs. Focus should be on leg muscles and trunk rotators, but not forgetting the upper body.

5.7 Nutrition

Alpine ski training and snowboarding have high energy demands. During training increased energy is chiefly produced through the addition of anaerobic pathways. This may cause depletion of glycogen and affect acid-base balance. In order to maintain performance level and power output, slowing the depletion of muscle glycogen becomes very important. This can be achieved by maintaining circulating glucose via supplementation or increasing the rate of glycogen resynthesis during recovery. It is also very important to consume adequate amounts of fluids during training. Dehydration reduces blood volume, decreases glucose delivery to muscles and reduces buffering capacity. Skiers/snowboarders can experience premature fatigue if fluid intake and carbohydrate supplementation is inadequate. (Bacharach & Bacharach, 2009.)

It has been demonstrated that energy intake is usually too low when training on glaciers (Bacharach & Bacharach, 2009; Bacharach & Bacharach, 2010). Supplementing skier's diet with 500-600 calories during training seems to provide enough extra energy for a whole training session. Skiers who ingested carbohydrate-protein gel experienced less fatigue compared with skiers who ate ordinary snacks during training. (Bacharach & Bacharach, 2009.) It is recommended that snowboarders should have carbohydrate-containing or carbohydrate-protein-containing fluids available at the start or finish of a run. During 2 hour slalom training with no fluid intake alpine skiers lost 0,6kg of their body weight. To prevent excessive dehydration snowboarders should drink at intervals of 15-20 minutes. (Bacharach & Bacharach, 2009; Meyer et al., 2011.) The micronutrients of special interest for winter sport athletes are iron, antioxidants, and vitamin D. Also sport supplements including blood buffers, creatine and caffeine may provide benefit for snowboarders. During snowboard cross and parallel event competitions there's multiple heats with varying breaks in between. It is important to make fuelling strategies aimed to maintain carbohydrate availability to prevent glycogen depletion. Food consumed between runs should be easily digestible and include carbohydrate-rich sources. (Meyer et al., 2011.)

6 TRAINING PERIODIZATION

Training programs should always meet the needs and goals of a specific athlete within the context of the sport. Training periodization is challenging for snowboarding, because it is a sport in which the athlete is required to have good aerobic fitness, anaerobic capacity, muscle strength and power as well as balance and agility. To plan training of all these qualities without compromising each other is difficult. Another challenge for periodization is a long competitive season which lasts for months. Athletes might be travelling 6 weeks in a row from competition to another without good physical training facilities. During competition season it is also important to plan enough rest to avoid burn-out at the end of the season.

When planning a program for the athlete a key to performance improvement is progressive overload. When elite athlete is concerned there has to be a variation in the loading paradigms. (Bompa & Haff, 2009. p. 55.) Acute program variables are e.g. a choice of exercise, order of exercise, number of sets, rest periods, load or resistance used and velocity of movement (Kraemer & Häkkinen, 2002. p. 44-53). In alpine skiing and probably also in snowboarding, riders need high levels of strength, power and strength endurance (McAlpine, 2010; Müller et al. 2000; Turnbull et al. 2009; White & Johnson, 1991). In order to achieve this, the athlete should include maximal strength training, power training, strength endurance training as well as hypertrophic training on their training program. There is no consensus which of these qualities is the most important one, because of contradictory results from studies (Turnbull et al. 2009).

It is easier to plan and manage a training program when the annual training plan is divided into smaller training phases. The purpose of periodization is to structure training phases to stimulate physiological and psychological adaptations. Training phases are sequenced to progressively develop specific components of performance. How annual training plan is divided depends on the sport. Usually annual training plan is divided into preparatory, competitive and transition phases. During preparatory phase foundation to performance is build, whereas the competitive phase is the time of maximizing performance capacity. Transition phase is for athletes to recover from the physiological and psychological stresses of the competitive season. (Bompa & Haff, 2009 p. 126-128.)

Two major types of periodization are most widely used, when planning a strength training program for athletes. First one is classic, *linear periodization* and second one is *non-linear periodization*. Linear periodization programs start with high volume and low-moderate intensity. Volume is gradually decreased and intensity increased. Linear training plans are long lasting programs and might take several months to complete. Training phase with a same volume and intensity usually lasts approximately 4-6 weeks (mesocycle). During one macrocycle usually one particular training zone is trained e.g. hypertrophy or maximal strength. Consecutive mesocycles share a different goal, but often goal of the linear periodization programs is to peak strength/power after the last macrocycle (Picture 4). Nonlinear periodization changes training volume and intensity either on the daily basis or less frequently at periods of one or two weeks. Daily nonlinear periodization is targeted to change training zones in consecutive training sessions. This means that number of repetitions as well as intensity of the training changes between strength training sessions (Picture 5). Also nonlinear programs have been developed, where a particular training zone is utilized for a one or two weeks. (Fleck, 2011.) Breil et al. (2010) investigated how 11-day high-intensity endurance training program affected alpine skiers maximal oxygen consumption and performance. They found a significant increase in maximal oxygen consumption and 90s jump-test in the training group. No changes occurred in control group. On the contrary, they demonstrated decrease peak power for the training group in countermovement jump and squat jump. Authors concluded that decreased jump power was due to a persisting muscle fatigue.

Block and emphasis	Week	Sets	Repetitions	Intensity Monday	Intensity Wednesday	Intensity Friday
	1	3	10	M	ML	L
1: Strength/Endurance	2	3	10	MH	M	L
	3	3	10	H	M	ML
	4	3	5*	M	M	L
2: Strength	5	3	5*	MH	MH	L
	6	3	3*	H	H	ML
	7	3	2*	VH	H	ML
	8	5	5	M	H	L
3: Power	9	3	3*	H	MH	ML
	10	1	3*	VH	M	ML

Exercises

Day	Block 1	Block 2	Block 3
Monday/Friday	Back squat	Back squat*	1/4 back squat*
	Behind-neck press	Push press*	Weighted jump§
	Bench press	Incline press*	Push jerk*
			Incline dumbbell press
Wednesday	Power snatch	Power snatch	Power snatch
	Clean grip shrug	Clean grip shrug	Midthigh pull
	Midthigh pull	Mid high pull*	Stiff-leg dead lift
	Stiff-leg deadlight	Stiff-leg dead lift	
	Dumbbell rows	Dumbbell rows	

Note: *Down set of 1 × 5 at approximately 60% of target sets; §0–30% of body mass. Intensities were based on a projected maximum for sets and repetitions (based on Stone et al, 2007). L = light (approximately 65–70% of 1-RM); ML = moderate light (approximately 70–75% of 1-RM), M = moderately (approximately 75–80% of 1-RM), MH = moderately heavy.

Picture 4. An example of linear strength training periodization protocol in a study (Painter et al. 2012).

Day	Emphasis	Sets	Repetitions	Intensity
Monday	Strength/Endurance	3	8–12	8–12 RM
Wednesday	Strength	3	5–7	5–7 RM
Friday	Power	3	3–5	3–5 RM

Exercises

Monday	Wednesday	Friday
Back squat	Back squat	1/4 back squat
Midthigh pull	Clean grip shrug	Midthigh pull
Behind-neck press	Push press	Weighted jump§
Bench press	Incline bench press	Push jerk
Dumbbell row	Dumbbell row	Stiff-leg dead lift

Note: RM = repetition maximum; §0–30% of body mass.

Picture 5. An example of nonlinear strength training periodization protocol (Painter et al. 2012).

Table 1 below presents one example of an annual training plan for a SBX/parallel event rider. When and how much on-snow training the athlete will have depends on the weather and training possibilities. On-snow training dates in this calendar are not meant to be ideal, but more what might be realistic. Transition phase consists of overall fitness exercises. Strength and endurance exercises can be low-volume and low-intensity. Most important goal of transition phase is to have physiological and psychological rest period. Strength training could be e.g. circuit training and endurance training e.g. ball-games. Sometimes on-snow training continues during transition phase. On-snow training at the time of preparation phase often happens in glaciers. Main focus is naturally on snowboarding during on-snow training period. Strength training concentrates on power, which means e.g. plyometrics. No additional endurance training is necessary, because snowboarding sessions might take already four hours.

During off-snow preparation phase endurance training is divided into aerobic training, high intensity training and speed endurance. Aerobic endurance part consists of low- and moderate-intensity training. Exercise can be either continuous or interval type of exercise. HIT periods are one week of duration with focus in a high-intensity endurance exercise. Training sessions are performed with same pattern as in Breil et al. (2010) study. One session is 4x4 min at 90-95% of max. heart rate separated by 3 min recovery periods. Speed endurance training includes both maintenance and production training (details in chapter 5.2). At the beginning emphasis is more on maintenance training and toward end of preparation phase emphasis will be more on production training. During maintenance phase endurance is trained approximately once a week.

Speed and agility training is exercised 2-3 times per week during preparation phase. Balance is trained together with strength training and also separately 1-2 times a week. Flexibility exercises should also be part of athletes training plan. They can be included as a separate stretching exercise or part of warm-up routine or recovery routine.

Table 1. An example of an annual training plan for SBX/PGS or PSL rider.

<table>
<tr><th>wk</th><th>Month</th><th>Phase</th><th>Snow training</th><th>Strength</th><th>Endurance</th></tr>
<tr><td>14</td><td rowspan="4">Apr</td><td rowspan="3">Transition</td><td rowspan="3">On-snow</td><td rowspan="3">Overall</td><td rowspan="3">General endurance</td></tr>
<tr><td>15</td></tr>
<tr><td>16</td></tr>
<tr><td>17</td><td rowspan="29">Preparation</td><td rowspan="16">Off-snow</td><td rowspan="16">16-week block</td><td rowspan="4">Aerobic endurance</td></tr>
<tr><td>18</td><td rowspan="5">May</td></tr>
<tr><td>19</td></tr>
<tr><td>20</td></tr>
<tr><td>21</td><td>HIT</td></tr>
<tr><td>22</td><td rowspan="3">Aerobic/ speed endurance</td></tr>
<tr><td>23</td><td rowspan="4">Jun</td></tr>
<tr><td>24</td></tr>
<tr><td>25</td><td>HIT</td></tr>
<tr><td>26</td><td rowspan="3">Speed endurance 1</td></tr>
<tr><td>27</td><td rowspan="4">Jul</td></tr>
<tr><td>28</td></tr>
<tr><td>29</td><td>HIT</td></tr>
<tr><td>30</td><td rowspan="3">Speed endurance 2</td></tr>
<tr><td>31</td><td rowspan="5">Aug</td></tr>
<tr><td>32</td></tr>
<tr><td>33</td><td rowspan="3">On-snow</td><td rowspan="3">power</td><td rowspan="3">Specific endurance (on-snow)</td></tr>
<tr><td>34</td></tr>
<tr><td>35</td></tr>
<tr><td>36</td><td rowspan="4">Sep</td><td rowspan="3">Off-snow</td><td rowspan="3">3-week block</td><td rowspan="3">Speed endurance 3</td></tr>
<tr><td>37</td></tr>
<tr><td>38</td></tr>
<tr><td>39</td><td rowspan="3">On-snow</td><td rowspan="3">power</td><td rowspan="3">Specific endurance (on-snow)</td></tr>
<tr><td>40</td><td rowspan="5">Oct</td></tr>
<tr><td>41</td></tr>
<tr><td>42</td><td rowspan="4">Off-snow</td><td rowspan="4">4-week block</td><td>rest</td></tr>
<tr><td>43</td><td>HIT</td></tr>
<tr><td>44</td><td rowspan="2">Aerobic endurance</td></tr>
<tr><td>45</td><td rowspan="4">Nov</td></tr>
<tr><td>46</td><td rowspan="3">Precomp.</td><td rowspan="3">On-snow</td><td rowspan="3">Maintenance</td><td rowspan="3">Maintenance</td></tr>
<tr><td>47</td></tr>
<tr><td>48</td></tr>
<tr><td>49</td><td rowspan="4">Dec</td><td rowspan="17">Competition</td><td>Off</td><td>power</td><td>Speed end.</td></tr>
<tr><td>50</td><td rowspan="16">On-snow</td><td rowspan="16">Maintenance</td><td rowspan="16">Maintenance</td></tr>
<tr><td>51</td></tr>
<tr><td>52</td></tr>
<tr><td>1</td><td rowspan="5">Jan</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td rowspan="4">Feb</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td><td rowspan="4">Mar</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td></tr>
</table>

In this example of annual plan periodization of strength training has been done based on Steven Plisk's periodization strategies (Haff, 2004; Plisk & Stone, 2003). 16-week training program (Picture 6 and 7) is divided into 4 different blocks. Weeks 1-4 and 9-12 have the same kind of strength training schedule like weeks 5-8 and 13-16.

Sixteen-Week Summer Program: Blocks 1 and 3 (Plisk)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Strength & power 1	Strength & power 2 Speed & agility 1		Strength & power 3	Strength & power 4 Speed & agility 2	
	Strength & power 5	Strength & power 6 Speed & agility 3		Strength & power 7	Strength & power 8 Speed & agility 4	
	Strength & power 9	Strength & power 10 Speed & agility 5		Strength & power 11	Strength & power 12 Speed & agility 6	
	Restitution 1			Restitution 2		

Picture 6. Strength training program by Steve Plisk. Blocks 1 and 3 include training weeks 1-4 and 9-12. 4th week of the program is a rest week with low volume training. (Haff, 2004.)

Sixteen-Week Summer Program: Blocks 2 and 4 (Plisk)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Speed & agility 1	Strength & power 2	Speed & agility 2	Strength & power 2	Speed & agility 3	
	Speed & agility 4	Strength & power 3	Speed & agility 5	Strength & power 4	Speed & agility 6	
	Speed & agility 7	Strength & power 5	Speed & agility 8	Strength & power 6	Speed & agility 9	
	Restitution 1		Restitution 2		Restitution 3	

Picture 7. Blocks 2 and 4 include training weeks 5-8 and 13-16 (Haff, 2004).

Blocks 1 and 3 (weeks 1-4 and 9-12) include 4 strength/power sessions per week and 2 speed/agility sessions per week. Blocks 2-4 include 2 strength/power sessions per week and 3 speed/agility sessions per week. After each block there is restitution. For snow-boarding it might be more appropriate to change one of the speed and agility sessions during blocks 2 and 4 to be a speed endurance session. Volume load progresses from low/moderate during first week of block, moderate/high during second week and high/very high during third week. (Haff, 2004.) 3-week and 4-week blocks are also planned in the same style. Last week of each block is restitution block. Below is an example week from 16-week block.

Table 2. An example of training schedule for week 11 in 16-week training plan.

Week 11	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Morning	Strength/ power balance(int.)	Strength/ power	Balance	Strength/ power	Strength/ power	Speed Endurance (production)	
Afternoon	Speed Endurance (production)	Speed & Agility			Speed & Agility		
Evening	flexibility				flexibility		

In this example there are two "production" speed endurance exercises. First balance training of the week is integrated with strength training and second one is done separately. Speed and agility sessions are done in afternoon and also not after rest day. Sometimes it might be good to do speed and agility exercises after rest day with "fresh legs". During week 11 strength training focuses on maximum force with high loads (1-5 RM) and also on power production with loads around 30% of maximum and repetitions 1-5. This type of training includes only the major muscle groups needed in snowboarding. Other muscles like trunk stabilizers may be trained using repetitions 15-20, 12-15 and 8-12. Plyometric training is part of the power training in the schedule. Flexibility training can be either long (30s-90s) static stretches or dynamic stretching. Above is presented a possible training plan for SBX, PSL or PGS rider. When training according to any training plan it is very important for athlete to feel his own body and adjust exercises according to fatigue or psychological state. Also it is very important to individualize training according to person's needs and goals. Some may require more strength training and others more endurance training.

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