Task 1 – Energy Systems
National Coaching Institute Ontario

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Alpine Ski Racing

Overview of the Sport

On the most basic level, the sport of Alpine Ski Racing can be explained as a timed sport in which the athlete that goes from starting gate to finish line the fastest wins. Similar to other timed sports such as track and swimming, the sport of Alpine Ski Racing actually consists of several distinct disciplines or events. Each of these disciplines has different energy requirements that are linked to the duration of the event.

By way of a brief explanation, these events include Slalom (SL), Giant Slalom (GS), Super Giant Slalom (SG), and Downhill (DH). Slalom is the shortest event, requiring the quickest turns. For the age group that we work with (15-29 years), a Slalom run can demand between 45 to 50 turns with a race being comprised of 2 runs. A Giant Slalom race is also determined by the accumulated time from 2 runs. The turns are executed over a slightly longer time frame than in Slalom with a greater distance between turns resulting in the athlete traveling at a higher velocity. The number of gates is based upon a percentage of the vertical drop of each specific hill. In Southern Ontario a typical GS run consists of 20 to 25 turns. The speed events of Super Giant Slalom and Downhill really require bigger hills than we have in Southern Ontario, but our Provincial Organization still runs events under those names for our athletes. For the purpose of this report, we have chosen to focus only on the technical events of Slalom and Giant Slalom.

With most technical events running between 30 seconds to 1 minute per run, a race is predominantly anaerobic. However, training days last between 2 to 6 hours in order to maximize sport-specific training opportunities during the short ski season. This training load requires the athletes to have sufficient aerobic capacity for endurance and recovery. Travel and environmental factors such as altitude and temperature place additional stress on the athletes throughout the season.

While there is not a wealth of information available regarding our sport, the physiological demands were initially described in the literature in 1965 by Saltin et al (Bacharach, DW et al). The level of intensity during training and competition can reach between 75-100% of maximal aerobic power (Tesch, PA). Over the course of a training day, the associated high rate of glycogen utilization can result in a depletion of stores (Tesch, PA). Some research has shown a correlation between high levels of aerobic power and performance (Neumayr, G et) while others found no such link (Tesch, PA). Theoretically, it is likely that the athlete's VO2max and the percentage of V02max that can be maintained for a prolonged period of time factor strongly into performance. A study of the Austrian National Team that has dominated our sport over the past decade found that athletes at the highest level have V02max levels of 55ml/kg/min for women and 60ml/kg/min for men (Neumayr G, et al).

<u>Estimated Contributions of Energy Systems by Discipline</u>

(based upon information from I. Balyi)

Slalom

Average duration:	40-60 seconds / run
Anaerobic Alactic:	50%
Anaerobic Lactic:	40%
Aerobic:	10%

Giant Slalom

Average duration:	70-120 seconds / run
Anaerobic Alactic:	45%
Anaerobic Lactic:	40%
Aerobic:	15%

<u>Analysis of Energy Expenditure</u>

Because ski racing is a timed event, the athlete is in motion from the time that they trigger the start wand until the time that they cross the finish line. There are no pauses or rests…unless something has gone horribly wrong. Therefore, the athlete is active at levels of 75-80% of their VO2max for the entire 30-120 seconds. The format for the Time/Motion Analysis decided upon for the purposes of this task involved the identification of motions around several joints. The motions involved in skiing are typically defined in terms of flexion and extension at the ankle, knee, and hip. By looking at a single turn in each of the two technical events, we have charted the duration of time that each joint moves through these ranges of motions. The chart also allows us to look at the sequence of motion across the joints.

One of the first challenges in this exercise was to determine the start and finish of a single turn. Because a ski race requires the athlete to link one turn into the next, there is no obvious end point. For several years, the Canadian Ski Coaches Federation has divided a single turn into 3 distinct phases. This has been done for the purpose of educating athletes and coaches of the ideal technique. We found that this framework did fit well with the task at hand. We chose to use the identifiable event of the athlete's skis being flat/neutral in the ski turn to indicate the start and end of the turn. For this reason, we have data that shows the skier to go through a movement pattern of extend/flex/extend rather than the traditional concept of a turn being simply flex/extend. Our criterion has split the extension phase between the start and the end of the turn.

This analysis was performed using one of our current athletes as the subject. The footage was shot with a Sony mini DV Digital Handycam, model TRV18. Time of motion was calculated based upon the standard 30 frames per second.

Table 1: Time Motion Analysis of a Single GS and SL Turn

JOINT	Frame In	Frame Out	Total Frames	Total Time	Motion
1. GS Turn					
Hip	0	7	7	.23 sec	Extension
	7	29	22	.73 sec	Flexion
	29	40	11	.37 sec	Extension
Outside Knee	0	7	7	.23 sec	Extension
	7	20	13	.43 sec	Neutral
	20	28	8	.27 sec	Flexion
	28	40	12	.40 sec	Extension
Inside Knee	0	6	6	.20 sec	Extension
	6	24	18	.60 sec	Flexion
	24	40	16	.53 sec	Extension
Outside Ankle	0	27	27	.90 sec	Neutral
	27	35	8	.27 sec	Flexion
	35	40	5	.17sec	Extension
Inside Ankle	0	29	29	.97 sec	Neutral
	29	34	5	.17 sec	Flexion
	34	40	6	.20 sec	Extension
2. SL Turn					
Hip	0	5	5	.17 sec	Extension
	5	15	10	.34 sec	Flexion
	15	25	10	.34 sec	Extension
Knees	0	16	16	.53 sec	Flexion
	16	25	9	.30 sec	Extension
Ankles	0	4	4	.14 sec	Neutral
	4	15	11	.37 sec	Flexion
	15	23	8	.27 sec	Extension
	23	25	2	.07 sec	Neutral

From this chart, we can observe that in this specific case, it took 1.33 seconds to complete one GS turn and 0.83 seconds for one SL turn. It is obvious that the athlete does not have any true pause/rest times during a ski turn. The ankle joint does appear to have some periods of time during the turn during which it is neither flexing nor extending. It is hypothesized that this may be a function of the stiffness of the boot or the level of sophistication of the information gathering equipment utilized in this study. Regardless, there is motion in the other 2 joints even during times of no motion at the ankle. In both types of turns, it appears that the hip initiates the motion in the lower body of this specific athlete.

A technical ski race is comprised of 2 runs. While the athlete is never at rest during either run, there are rest components associated with lift rides and the time between runs. A race day involves an early start with time for a few warm-up runs. These runs may require 80-100% intensity. This activity is followed by inspection during which the athlete moves very slowly down the hill for 20-30 minutes. An athlete may wait between 10 minutes to one hour for their turn on course. A break occurs between runs as the course must be reset for the second run. This creates another rest block of up to one hour. The warm-up / inspection / race routine is then repeated. It is therefore necessary for an athlete to have the ability to both produce and tolerate lactic acid as well as having good aerobic capacity in order to meet the demands of race day.

Development of Required Energy Systems

The following sections provide information regarding the specific energy systems required throughout a training or race run and over the duration of a training day. Examples are provided of timing and type of activity specific to skiing, when the system should be trained and maintained during the year, as well as suggested training protocols.

1. Anaerobic Alactic Power

Duration:	0-5 seconds
Activity/Skill:	Starts, quick movements (eg increase/decrease of edge angle)
Train:	Pre-comp
Maintain:	Gen. Prep, Specific Prep, Comp
Training type:	Intervals, plyo's
Frequency:	3/wk
Work to Rest Ratio:	2-5 sec : 6-15 sec (1:3)
Reps:	5-7
Sets:	2-4

2. Anaerobic Alactic Capacity

Duration:	10-30 seconds
Activity/Skill:	constant pressure through longer turns
Train:	Pre-comp
Maintain:	Gen. Prep, Specific Prep, Comp
Training type:	Intervals
Frequency:	3/wk
Work to Rest Ratio:	15-30 sec : 90-180 sec (1:6)
Reps:	2-4
Sets:	2-4

3. Anaerobic Lactic Power

Duration:	20-30 seconds
Activity/Skill:	quick movement to recover late line
Train:	Specific Prep
Maintain:	Gen. Prep, Pre comp, Comp
Training type:	Intervals
Frequency:	3/wk
Work to Rest Ratio:	20-30 sec : 100-150 sec (1:5)
Reps:	6-9
Sets:	4-6

4. Anaerobic Lactic Capacity

Duration:	45-120 seconds
Activity/Skill:	strong completion of courses
Train:	Specific Prep
Maintain:	Gen Prep, Pre comp, comp
Training type:	Intervals
Frequency::	3/wk
Work to Rest Ratio:	60-90 sec : 240-360 sec (1:4)
Reps:	2-3
Sets:	2

5. Aerobic Power

Duration:	1 – 10 minutes
Activity/Skill:	lactate accumulation in long courses (eg DH, SG)
Train:	Gen. Prep
Maintain:	Specific Prep, Pre comp, Comp, Transition
Training Type:	Intervals
Frequency:	3-4/wk
Work to Rest Ratio:	1-3 min : 1-3 min (1:1)
Reps:	6-10
Sets:	1-2

6. Aerobic Capacity

Duration:	45-120 minutes
Activity/Skill:	long training days, long season, travel
Train:	Gen. Prep
Maintain:	Specific prep, Pre comp, Comp, Transition
Training type:	Continuous
Frequency:	4-6/wk
Duration:	45 – 60 minutes

Testing / Monitoring of the Energy Systems

Laboratory testing utilized for the athletes at the elite/National Team level are beyond the accessibility of our athletes. Therefore field-testing protocols are more applicable. Tests include the Leger ("beep") test to predict V02max. The advantages of this test are the lack of specialized equipment required, the portability, the reproducibility, and the ability to test many athletes at one time. When performed in a group situation it also introduces an element of competition that helps to mimic the racing environment. Also, athletes are able to remember past performance levels. The disadvantages of the test are the specificity to running, the stop/start nature of the 20m shuttle, and that it provides only a predicted level of aerobic capacity.

Five consecutive jumps has traditionally been used as a test of anaerobic alactic power. The five jumps take approximately the same time as traveling from start gate to the first gate of a GS course. In skiing, the athlete would push out of the start utilizing a coordinated effort of arms and legs, followed by a few hard skating strides. The forward jumps do not mimic the skating motion, so we are playing with substituting a series of lateral jumps from one leg to the next.

The 400m run is often utilized to determine anaerobic lactic capacity. Other options include a variety of shuttle type runs of durations ranging from 45 seconds to one minute. Again, most of these are influenced by the athlete's running ability.

Conclusions and Self Evaluations

Alpine Ski Racing is an anaerobic sport with a heavy dependence upon an athlete's aerobic capacity in order to train effectively. For this reason, all of the energy systems must be trained throughout the season in a highly coordinated plan that limits any interference between the development and maintenance of the individual systems. This is the challenge of coaching.

We believe that we are currently managing these needs effectively as evidenced by our past athletes' abilities to finish races strongly and the lack of "burn-out" at the end of the season. In the past we have run our own program from design to delivery. Last season, we were both working within the confines of someone else's program design. This season we are working together with the freedom to once again create our own program. We have introduced individualized training programs to this group and will continue to train according to the principles of science. Generally, we would like to see several of our current athletes increase their aerobic capacity and power. In the past we have focused on developing and maintaining this system while placing a secondary emphasis on the anaerobic system. Following this work, we will increase the focus on the anaerobic. The biggest challenge to the development of a truly sound training plan with this group is the element of time. We do not work with the athletes directly over the full year and several of the athletes are also involved in other sports and we must be mindful of those specific energy requirements. In addition, the athletes have the time demands and stresses that come with being full time high school students. Again, this is the challenge of coaching.

References

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