HUMAN MOVEMENT

BIOMECHANICS OF TACTICS OF RUNNING A COURSE IN FOUR ALPINE SKIING DISCIPLINES: FIRST COURSE GEOMETRY RESULTS

DOI: 10.2478/v10038-008-0016-5

Włodzimierz S. Erdmann*, Piotr Aschenbrenner
Chair of Biomechanics and Technology, J. Śniadecki University School of Physical Education and Sport, Gdańsk, Poland

ABSTRACT

**Purpose.** The aim of the overall research on alpine skiing was examination of the biomechanical approach to tactics of running a course. The aim of this particular paper was presentation of first results on the geometry of courses of four disciplines. **Basic procedures.** The research covered competitions of alpine skiers during the 2006/2007 FIS World Cup. All four alpine skiing disciplines, i.e. downhill, super giant, giant slalom, and slalom, were taken into account. Each discipline was studied three times: in Italy, Austria, Germany, Slovenia, and Norway. 54 to 82 alpine skiers took part in each of the competitions. Differential GPS for geometry of gates setting and video camera for time data were used. Then the distribution of velocity for each runner along the entire course was calculated. **Main findings.** The first data on geometry of the ski courses revealed a large difference in vertical drop and length between the disciplines, with the angles of inclination, however, being similar. **Conclusions.** The knowledge of detailed geometry of ski courses is important since up to one-third of competitors do not finish particular runs. It happened that as many as ten skiers ran off the course at the same gate.

Key words: alpine skiing, downhill, super giant, giant slalom, slalom, tactics, geometry, course

**Introduction**

Good sport results in alpine skiing depend on skiers’ general fitness preparation, technical skills as well as the quality of equipment, suits and waxing. A very important component of the final success is also proper course running tactics.

The course running tactics expressed in biomechanical quantities include: (a) choice of course line between the gates (optimization of the course run); (b) choice of running technique, accounting for relief of the trail and snow conditions (minimization of air drag and snow friction); (c) choice of proper velocity at particular sections of the course regarding the course geometry; and (d) distribution of velocity along the entire course (to complete and endure the run in the most efficient way possible, without running off the trail, hitting the poles, or sustaining injuries). According to Weibel [1] the most challenging elements of the course for alpine skiers are steepness, small offsets between the gates, sinusoidal sections of the course (angles of deviation) and changes of the running rhythm. Unfortunately, the concept of velocity distribution, although significant, has been rarely subject to serious research. Having consulted top FIS World Cup trainers and skiers the authors noted their general negligence of tactical aspects of velocity distribution along the entire skiing course.

At the turn of the 20th and 21st centuries course running in alpine skiing was fragmentarily studied. The aspects researched included inter-gate way, centrifugal forces, the influence of body build on running, technique of running and forces between the ski boot and the binding as well as between the ski boot and the ski [2–5].

Erdmann et al. [6–11] studied the setting of gates along the giant slalom course and velocity distribution along the entire course. Their investigations were made with the use of measuring tape applying the triangulation formula, and with a goniometer for measuring the angles of inclination. Other studies used a theodolite (a surveying instrument). The time of course completion as well as inter-gate times were obtained from the video footage from the camera positioned at the finish area of the FIS World Cup courses. Then the velocity and its distribution along the entire course were calculated. The data obtained was used for assessment of all skiers’ course running tactics. It was observed that

*Corresponding author.
a number of skiers raced too actively at the initial parts of the course. They gained some better time initially but finished later, ran off the trail or failed to complete the run.

The general purpose of our research was to examine the biomechanics of tactics of running an alpine skiing course in four disciplines: downhill (DH), super giant (SG), giant slalom (GS) and slalom (SL). The present paper reveals the first results on the geometry of skiing courses.

**Material and methods**

The study sample consisted of skiers taking part in the 2006/2007 FIS World Cup. 54 to 82 alpine skiers took part in each discipline. Each of the four alpine skiing disciplines was examined three times: in Selva Gardena/Wolkenstein (Val Gardena/Gröden) and La Villa (Alta Badia) in Italy, Hinterstöder (Austria), Garmisch-Partenkirchen (Germany), Kranjska Gora (Slovenia) and Lillehammer-Kvitfjel (Norway).

The setting of the gates on all the skiing courses under study was examined using the Differential Global Positioning System (DGPS), with one fixed GPS reference station and the other placed at every pole around which a given skier made his turn. The accuracy test of DGPS carried out from a ski lift registered the course run in a straight line. Additionally, the video footage of each skier’s run from the big broadcast screen at the finish area was used for analysis. The video recording yielded data on skiers’ times while passing next to consecutive gate poles. The obtained inter-gate times and distances allowed calculating the mean velocity between the gates as well as assessing the tactical distribution of velocity along the entire course.

**Results**

The study results concerning the geometry of selected alpine skiing courses revealed great differences in the length and vertical drop of the courses. Fig. 1 presents a comparison of the skiing courses under study (top view). The curve shows a set of distances between the gates. Fig. 2 presents a sample course with the setting of gates around which the skiers made their turns. Fig. 3 shows a comparison of profiles of courses of the four skiing disciplines, formed by descent lines running through the gates. A sample profile and its axonometric projection showing the setting of the gates are shown in Fig. 4.
W. S. Erdmann, P. Aschenbrenner, Biomechanics of tactics of running a skiing course

Discussion

The organizers of alpine ski competitions provide information about the elevation of the course start and finish as well as about slope characteristics. These data enabled calculation of the vertical drop. They also give information about the length of the course, however without the geometry of gates setting. Detailed knowledge about the geometry of a ski course, which accounts for the setting of the gates, in particular, about the setting of turning poles can definitely contribute to skiers’ faster completion of the run. The organizers usually allow trainers and skiers to get acquainted with the geometry of the course and gates for one hour before the competition. Unfortunately, a configuration of several dozen gates is difficult to remember, thus it happens that about one-fourth or even one-third of participating skiers fail to complete the run. The run completion can be also affected by skiers’ improper distribution of physical effort. As Aschenbrenner [12] observed in his study of alpine skiers during the Winter Olympic Games in Lillehammer, competitors who had the best times after covering one-fourth or one-third of the entire distance, were not able to maintain the same level of activity until the end and finished their runs with much worse times.

References
