A TRAINING AND TESTING ERGOMETER FOR LEG POWER IN SKLING

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INTRODUCTION

The research project involves the dcvelopmcnt of an ergometer for the testing and training of leg strength and power in skiing. The project is currently in progress with new developments and upgrading taking place as a result of ongoing testing and research.

In order to maximize performance, coaches and athletes require highly specific physical performance measures to assess the athletes' readiness for competition. There is currently a need for an effective testing device for ski related events which require maximal leg power. The training and testing ergometer is designed to provide accurate measures to indicate training levels during off and pre season preparation plus the measurement of competitive season readiness. The objective is to reproduce similar body and muscle mechanics to those experienced in each ski event. In particular the Freestyle events, moguls and aerials plus the Alpine events Slalom (S), Giant Slalom (GS), Super Giant Slalom (SGS), and Downhill (D) require mechanics which can be simulated on the ergometer.

The system is fully computerized and designed for ease of operation. The device is designed to record anaerobic power output produced through both eccentric and concentric muscular forces during simulated ski motions. The current leg power tests used by ihe Canadian skiers (40 sec. Wingate, Margaria Power) are not motion specific and do not effectively represent the muscle contractile process required during skiing events (Sale and MacDougall, 1989). An excellent review of anaerobic tests (Vandewalle, 1987) discusses the various approaches to power testing. The accuracy advantages of the force plate are emphasized. The literature reinforces the need for anaerobic and strength performance measures for skiing (Orvanova 1987; Haymes, 1987-80; Brown, 1983; Eriksson, 1977-88; Andcrscn, 1988). In comparison to other winter sports, skiers maintain the highest isometric values for leg extension plus blood lactate levels (Eriksson, 1977). In addition to static isometric measures, of particular interest in the design of the testing device is the measurement of both eccentric and concentric contractile forces in the musculature controlling knee and hip motion. These motions are typical of freestyle moguls, aerials and slalom and are simulated with the rebounding motion of the skier on the sled. Of special significance is the eccentric force absorption process which occurs as the skier impacts irregular surfaces and absorbs forces in the legs at high velocities. Additional testing considerations are the significant performance factors resulting from continuous isometric contractions, the impedance of oxygen delivery and the limitations to anaerobic metabolism during Alpine events (Veicsteinas, 1984). The ergometer includes a specially designed adjustable resistance device which enables the simulation of the muscle contractile process in Alpine events.

ERGOMETEK DESIGN AND DESCRIPTION

The systein is of steel construction and is bolted firmly to the tloor. The sled's teflon wheels are set into railings which allow for low friction motion along an inclined track. The force

plate is fixed to the base of the adjustable inclined track which can be set between 0 and 35° to the horizontal. The force transducer plate is set at 100° to the track to allow for natural extension of the foot on impact and push off. The vertical impact forces are measured through a series of sixteen strain gauges linked through a Wheatstone Bridge system.

Fig. 1. Ski Ergometer Contact and Isometric Measures

The bridges are amplified and summed through an A/D converter and the 12 bit digital signal is manipulated using a high level language software package (A.S.Y.S.T.) programmed on a standard IBM PIC Computer. Real time curves from impact and push off appear on the screen during testing (fig. 2). The software uses analogue digital force conversion for the calculation of Force (Newtons), Work (Joules), Power (Watts). Eccentric and concentric reaction forces, limited range isometric contractions, contact and flight ratios plus fatigue decrement measures are optional. All forces are normalized to body weight for comparative purposes, eg. 80 kg mass 784 Newtons. A maximal force for take off may reach 3000 Newtons which is equal to 3.83 in terms of normalized force.

TEST PROTOCOL DESIGN

Test protocols are being developed and will result in appropriate changes to the system design and software (Table 1).

Tests vary depending on the ski event with emphasis placed on a single take off or landing as in ski jumping or a continuous motion as in freestyle moguls or Alpine events.

TEST RESULTS

The test results provide data based on the force time relationships produced by the force plate (fig. 2). Maximal and minimal vertical Force (Newtons) and Power (Watts), plus Relative Average Work (Joules/Kilogram) and Power (Watts/Kilogram) are provided. Power and Force decrements provide fatigue factors, plus Peak Maximal Force or Power for shorter single event tests e.g. 5-10 sec.

SKI EVENT DESCRIPTION FOR PROTOCOL DESIGN

TEST	TIME INTERVAL	MOTION TYPE	
		Turns	Contraction
Alpine			
Slalom	45 - 75 secs	50–70	turns-Ecc/Con/Isom
Giant **Slalom**	60 - 90 secs	35–45	**turns** - Isom
Super Giant Slalom	80 - 95 secs	30–35	turns - Isom
Downhill	120 - 180 secs	15–25	turns - Isom
Freestyle			
Moguls	30 secs		Ecc/Conc
Aerials	5 secs		
	5 secs		Ecc/Conc
Jumping			

Table 1. Conc=Concentric, Ecc=Eccentric, Isom=Isometric

COMPARATIVE POWER TEST

In order to provide a comparison to an alternate valid power test twelve subjects were tested on the ski ergometer and the Wingate Bicycle Power Test for a 40 sec maximal output. Positive correlations are indicated (Table 2). Due to the greater specificity of the ergometer and the flexibility for individual event testing the potential for test and training applications are promising.

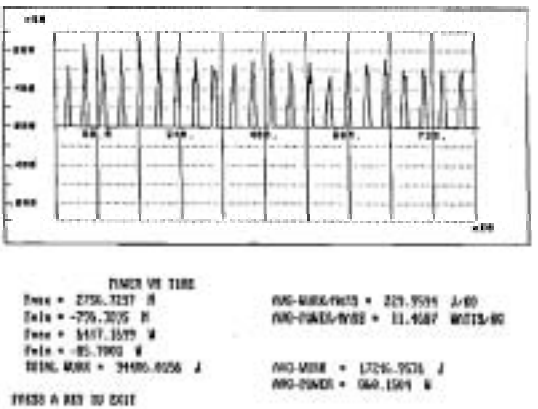

Fig. 2. Ski Ergometer Test Results

SUB.	WIN. AVPOWERW (Watts)	ERG AVPOWERS	WIN. AVWORKW (Joules)	ERG AVWORKS
x	507.1	1.201E+03	3.043E+04	2.362E+04
SD	111.4	268.3	6.688E+03	5.197E+03
Correlation	.6079		.6233	

Table 2. Work (J) Power (W) Test Output Correlations lor Wingate (WIN) and Ski Ergometer (Erg) (40 sec). N = 12

CONCLUSIONS

The inlormation provided in this report is the result of an ongoing project which will produce a testing and training system designed for ski coaches and athletes. The development of the project is the result of feedback and interaction between coaches at the Big Thunder Ski Training Centre in Thunder Bay, Canada and Lakehead University Biomechanics Laboratory.

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