Power and Strength Profiles of Elite 16-20 Years Old Ice Hockey Players

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INTRODUCTION

The sport of ice hockey has received considerable attention from researchers interested in the energy systems supporting high level competition. For example, Bonen and Babineau, 1977, Ferguson, Marcotte and Montpetit, 1969, and Montpetit, Ferguson and Marcotte, 1971 investigated the VO_2 max. of hockey players using various measurement and statistical prediction techniques. Other researchers have speculated that the nature of ice hockey requires high levels of anaerobic energy and the ability to recover quickly from a bout of high intensity exercise (Green, Bishop, Houston, McKillop, Norman and Stothart, 1976; Montpetit, Binetto and Taylor, 1969; Smith, Wenger and Quinney, Sexsmith and Steadward, 1980, Watson and Sargeant, 1986).

At present, there is little evidence of attempts to correlate physiological power to mechanical power of ice hockey players. Since skating, which is central to the game of hockey, requires a great deal of leg power, this variable would seem to be a basic prerequisite of effective performance. The purpose of the present study, therefore, was to investigate power and strength relationships in elite 16-20 year old ice hockey players. More specifically, an attempt was made to describe the relationships between various anaerobic power measures and the mechanical power exhibited by the leg muscles during a vertical jump task.

METHODS

Thirteen (13) subjects volunteered for the study. Each subject was a participant in the Ontario Major Junior A Hockey League and, therefore, all subjects were considered to be elite performers in their age group (16 to 20 years old). All testing took place in the Biomechanics and Physiology Laboratories of the Faculty of Human Kinetics at the University of Windsor.

Anaerobic power was determined through use of the Wingate 30 sec. bicycle ergometer test. The testing protocol followed standard procedures. Six counts per revolution were recorded on a Cardionics Ergometer. The load was set at a weight equal to .075 kg. per kg. of body mass. The number of revolutions per second was recorded throughout the 30 sec. test. Data were recorded and compiled into three separate readings: best second power, best 5 consecutive seconds power, and 30 second power. In each case, values were recorded in Joules per second.

Mechanical power was estimated by measuring leg power exhibited during a maximum effort vertical jump. Peak power was recorded using an A.M.T.I. Biomechanics Force Platform System and a Northstar Horizon Microcomputer. The software used was the A.M.T.I. PWR (Power) software package. In addition to power, body weight was recorded and a peak power/weight ratio was calculated for each subject. To complete a more precise profile of individual subject characteristics, grip strength, maximum number of push-ups, and number of sit-ups per 60 sec. were also recorded.

Statistical analysis included summary statistics on each of the variables measured. In addition, Pearson Product-Moment Correlation Analysis was employed to determine relationships between and among anaerobic and mechanical power scores. Statistical significance was accepted at $P<.05$.

RESULTS

The anaerobic power scores recorded on the thirteen subjects tested are listed in Table 1.

TABLE 1
Anaerobic Power Scores Measured
Using a Wingate Bicycle Ergometer Test
(N = 13)

ANAEROBIC POWER (J/s)

SUBJ.	BEST SEC.	BEST 5 SEC.	30 SEC.
1	882.0	787.9	646.8
2	911.4	886.9	710.5
3	1082.9	955.5	687.9
4	970.2	896.7	714.4
5	896.7	848.7	733.0
6	878.1	828.1	689.9
7	713.4	702.7	652.7
8	968.2	896.7	656.6
9	891.8	879.1	751.7
10	823.2	776.2	678.2
11	828.1	777.1	656.6
12	764.4	717.4	605.6
13	649.7	590.0	575.3
MEAN	848.4	796.4	673.8
S.D.	110.4	96.5	49.3

The mean «best second» power score was $\bar{x}$ = 848.4 J/s (s_D = 110.4) while the mean «best 5 consecutive seconds» score was 796.4 J/s (s_D = 96.5). These values are consistent with the peak power output of college age physical education students calculated from data presented by Smith (1987) which was 853.5 J/s. Finally, the mean power output measured over the entire 30 second test was $\bar{x}$ = 673.8 J/s (s_D = 49.3). Thus, not only did power drop off over the 30 second period, as would be expected, but the group became more homogeneous as is indicated by the lower standard deviation value.

Body weight, leg power, and a power / weight ratio for each subject are listed in Table 2. The power value represents the peak power recorded during a maximum effort vertical jump using both legs.

TABLE 2
Leg Power Measured Using
An AMTI Force Platform and
AMTI Power Software
(N = 13)

SUBJECT #	WT (N)	LEG POWER (J/s)	POWER/WT
1	748.7	4534.8	6.06
2	810.5	5488.1	6.77
3	868.3	5853.9	6.74
4	846.7	5356.1	6.33
5	779.1	5683.3	7.29
6	841.8	4876.1	5.79
7	712.5	4951.5	6.95
8	681.1	6036.8	8.86
9	828.1	5316.9	6.42
10	813.4	5081.1	6.25
11	828.1	5129.3	6.19
12	752.6	5089.0	6.76
13	668.4	4260.1	6.37
MEAN	778.1	5204.4	6.68
S.D.	59.9	500.5	.77

The mean weight of the subjects was $\bar{x}$ = 778.1 N (s_D = 59.9). Mean peak mechanical power generated by the legs during the jumping task was $\bar{x}$ = 5204.4 J/s (s_D = 500.5). In each instance, peak power occurred toward the end of the upward movement of the center of gravity which preceded takeoff. This was expected since power is determined as the product of force and velocity and both of these values peaked just prior to takeoff.

A power / weight ratio was determined to provide an indication of mechanical power per unit of weight. The mean value of this ratio was $\bar{x}$ = 6.68 (s_D = .77) and the individual ratios ranged from 5.79 to 8.86. The main thrust of the project was to determine the relationships between measures of anaerobic power and measures of mechanical power generated during a vertical jump task. A correlation matrix summarizing this portion of the project appears in Table 3.

TABLE 3
Pearson Product-Moment Correlations Between
Anaerobic and Leg Power Scores
(N = 13)

	ANAEROBIC MEASURES			MECHANICAL MEASURES		
	BEST SEC.	BEST 5 SEC.	30 SEC.	WT.	LEG POWER	LEG POWER WT.
BEST SEC.	—	.99*	.63*	.59*	.76*	.24
BEST 5 SEC.		—	.78*	.63*	.81*	.26
30 SEC.			—	.67*	.57*	−.01
WT.				—	.30*	−.50
LEG POWER					—	.67*
LEG POWER/WT						—

* Statistically Significant at $P < .05$.

The two shortest term anaerobic measures «best second» and «best 5 seconds» were found to be highly related ($r = .99$, $P < .05$). Also, both of these measures were correlated significantly with anaerobic power measured over the entire 30 second Wingate test ($r = .63$, and $r = .78$ respectively, $P < .05$). This would indicate that all three measures are valid representations of anaerobic power.

All three anaerobic power measures were found to correlate significantly with body weight ($r = .59$, $r = .63$ and $r = .67$ respectively, $P < .05$). This indicated that, in general, the heavier subjects had greater anaerobic power than lighter subjects.

The main question of interest centered on the relationships between anaerobic power and mechanical power. It was determined that statistically significant relationships existed between all three measures of anaerobic power and mechanical power of the legs during a jump task ($r = .76$, $r = .81$ and $r = .57$ respectively, $P < .05$). These values indicated that those subjects who possessed greater anaerobic power were also able to generate the highest mechanical power during maximal concentric contraction of the jumping muscles in the legs.

Although body weight was significantly related to anaerobic power, it was not related to the mechanical measure of leg power ($r = .30$, $P > .05$). Also, there was not a statistically significant relationship between weight and the power / weight ratio ($r = -.50$, $P > .05$), although generally, heavier subjects tended to have lower ratios. Finally, there was a significant relationship between leg power and the power / weight ratio ($r = .67$, $P < .05$) which indicated that the important factor in determining the power / weight ratio is power more so than weight.

To more fully profile the strength characteristics of the subjects, grip strength, maximum number of push-ups, and number of sit-ups in 60 sec. were recorded. Subject data along with summary statistics are presented in Table 4.

TABLE 4
Strength and Performance Characteristics
of Elite 16-20 Year Old Ice Hockey Players
(N = 13)

SUBJ. #	GRIP STRENGTH (N)	PUSH - UPS (Total)	SIT - UPS (# in 60 s)
1	1176	40	50
2	1176	53	56
3	1372	42	58
4	1147	47	63
5	1127	51	49
6	1128	36	41
7	1127	29	47
8	980	43	70
9	1064	64	53
10	1392	81	64
11	1068	45	50
12	1196	45	40
13	784	45	51
$\overline{X}$	1134	47	53
s	154	13	9

The mean grip strength of the subjects was $\bar{x} = 1134$ N ($s_D = 154$). On average, the subjects were able to perform $\bar{x} = 47$ ($s_D = 13$) push-ups. Finally, the mean number of sit-ups completed in 60 seconds was $\bar{x} = 53$ ($s_D = 9$). These values are consistent with data recorded on previous groups of subjects from a similar population (Marino, 1984).

DISCUSSION

The results of the present study revealed a statistically significant relationship between anaerobic power measures and mechanical power in the jumping muscles of the legs. The best 5 consecutive seconds anaerobic power score correlated with leg power at r = .81. This indicates that 66% of the variance in these variables was common to both ($.81^2 = .66$). It appears, therefore, that in the population of elite 16-20 years old hockey players, leg power provides a good indication of anaerobic power and, in fact, could be used in a predictive study.

It was somewhat surprising that leg power and body weight were not found to be significantly related; especially since weight was found to be related to anaerobic power. Also, weight did not play a major role in the power / weight ratio since there was no significant relationship between the two variables. Power was significantly related to the power / weight ratio and thus it appears that those subjects with the greatest leg power are able to overcome the gravitational force acting on the body more effectively than those with lower power regardless of weight. It should be pointed out as well, however, that although the correlation coefficient fell just short of statistical significance, a negative value indicated that, generally, heavier subjects may have had lower power / weight ratios.

SUMMARY

Thirteen elite 16-20 year old ice hockey players participated in the study and were tested for anaerobic and mechanical power as well as other general strength measures. The purpose of the study was simply to profile the power and strength characteristics of this population of subjects. Analysis of the results revealed several significant interrelationships and based on these findings, several conclusions are warranted: First, leg power in elite 16-20 year old ice hockey players is significantly related to several anaerobic power measures. Second, there is a significant positive relationship between body weight and anaerobic power of elite 16-20 year old ice hockey players. Finally, there is a significant positive relationship between leg power and a power / weight ratio of elite 16-20 year old ice hockey players.

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