THE EFFECTS OF NINETEEN WEEKS OF WRESTLING TRAINING ON THE MAXIMUM OXYGEN UPTAKE AND RELATED PARAMETERS OF COLLEGIATE WRESTLERS

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ABSTRACT

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By

Stan J. Dziedzic

The purpose of this study was to determine the effects of nineteen weeks of wrestling training on maximal oxygen uptake and related parameters. Twelve subjects ran until exhaustion prior to the wrestling season and again after nineteen weeks of training. Maximal oxygen uptake per kilogram of body weight, maximal oxygen uptake per kilogram of lean body mass, the economy of the run, and the percentage of body fat were determined for each subject on both testing days. Data were statistically analyzed using the t-test.

No significant differences attributable to the training were observed in the maximal oxygen uptake per kilogram body weight, maximal oxygen uptake per kilogram lean body mass, the economy of the run, or the changes in the percentage of body fat between the pre and post test. Slight but insignificant increases were observed in all the variable means except the amount of body fat.

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CHAPTER I

THE PROBLEM

The factors related to human physical performance have been a subject of interest to investigators for many years. The resulting body of literature serves as the base from which coaches and physical educators prescribe training programs. This research evidence indicates that training is infinitely complex with very specific responses to different types of programs. Although the research base increases the predictability of training effects in place of speculation based on limited field experience, there are still many unknowns.

One of the measures used frequently in longitudinal experiments to evaluate the effects of training programs upon physical work capacity of subjects is the maximal oxygen uptake ($\dot{V}O_2$ max.). The $\dot{V}O_2$ max., defined as the maximum aerobic power of the individual, is the largest quantity of oxygen a subject can take up per unit of time and per unit of body weight during exhaustive work. This cardiorespiratory component has been shown to correlate well with the length of time that an individual is able to perform high intensity work (12). The relationship is higher for events of over two minutes duration.

Wrestling was chosen for the investigation because of its interest to the investigator. Conditioning for wrestling is complex since weight reduction and dieting are usually involved, as well as wrestling training. The consequences of each varies; nevertheless, all effect the performance of a wrestler. It was of particular interest in this investigation to determine the alterations in the $\dot{V}o_2$ max. which take place during a season of training and competition.

Statement of the Problem

To determine the effects of a season's wrestling training on the maximal oxygen intake capacity of collegiate wrestlers.

Scope of the Problem

This study was confined to twelve members of the Michigan State University Varsity Wrestling Team completing the 1974-75 season.

Limitations

(1) The sample size (N = 12) is small.

(2) Each subject ran only on the two days of testing. No practice sessions were given before the actual testing.

(3) The differences in type and intensity of the training could not be controlled due to numerous

pre-existent individual differences such as morphology, psychological orientation to the sport, and personal wrestling styles.

CHAPTER II

RELATED LITERATURE

There are many studies which apply to the present investigation. These include studies on the technique of obtaining a $\dot{V}o_2$ max., the effects of pre-training level and training on $\dot{V}o_2$ max., and the predictability of physical work capacity and performance from acquired $\dot{V}o_2$ max. It is the purpose of this review to examine this literature.

In laboratory experiments the two most common methods used to obtain $\dot{V}o_2$ max. are the treadmill run and the bicycle ergometer. However, the bicycle ergometer elicits more of a specific training effect than the treadmill (24). That is, with the use of the bicycle ergometer in subjects unaccustomed to riding bicycles, a greater increase in $\dot{V}o_2$ max. may result apparently from learning to ride the bicycle. The bicycle ergometer in U.S. subjects has also been shown to yield on the average a lower maximal oxygen uptake value than running on the treadmill up a grade (7, 1, 9).

To yield valid results the treadmill run should meet certain criteria. Astrand and Rodahl (4) list five general requirements:

> (1) The work in question must involve large muscle groups, (2) the work load must be measurable and reproduceable, (3) the test conditions must be such that the results are comparable and repeatable, (4) the tests must be tolerated by all healthy individuals, and (5) the mechanical efficiency (skill) required to perform the task should be as uniform as possible in the population to be tested.

More specifically, the test must progressively overload the circulatory-respiratory capacity without impeding blood flow through the total heart-lung mechanism (19, 23). This can be achieved by using a five minute submaximal load which serves as a warm-up period (4) followed by a progressive increase in load, i.e., intermittently raise the grade 1 to 2½ percent while holding the speed constant at 7 m.p.h. (33).

It is important to illustrate how critical the initial level of physical activity is in evaluating the effectiveness of a training program to improve maximal aerobic power. Saltin et al. (1968) (29) found that in previously physically active subjects the $\dot{V}o_2$ max. improved only 4 percent after 50 days of training. Starting with a 20 day period of bed rest, another group of previously physically active subjects' $\dot{V}o_2$ max. were lowered 27 percent but the improvement after 50 days of training was increased to 34 percent or a net improvement of 7 percent. For the previously sedentary subjects the improvement after training was 33 percent without bed rest and 100 percent when preceded by 20 days of bed rest. Other authors have shown increases of from 8 to 44 percent with training of from

8 weeks to 51 months respectively, in previously untrained men (18, 20, 28, 29). In studies using trained athletes as subjects, the $\dot{V}o_2$ max. values were significantly higher but the increases as the result of training were significantly lower (10, 27, 2, 7).

There are other examples implying that there may be a ceiling of the aerobic power. Saltin and Astrand (6) ran two studies on Olympic champion skiers and found that after 8 years and 9 years of rigorous training both skiers' $\dot{V}o_2$ max. remained virtually the same (5.48 l/min to 5.60 l/min and 5.8 l/min to 5.88 l/min respectively). Comparative studies with Olympic athletes show that they have higher $\dot{V}o_2$ max. than their counterparts of lesser caliber (5, 8, 35). These were cross sectional studies and did not contend that the differences were due to the amount or intensity of their training program. It would seem possible that with different, more intensive programs, that the maximal oxygen intake values might have been higher.

The maximum oxygen uptake can be separated into $\dot{V}o_2$ max. standard (liters O_2 uptake/kg. body wt.) and $\dot{V}o_2$ max. lean body mass (LBM). The "standard" uses total body weight as a denominator, while the (LBM) uses fat free weight as a denominator. Its role in exercise physiology seems unclear. In 1954 Buskirk and Taylor (8) advocated calculating $\dot{V}o_2$ max. per unit of fat free weight. They felt that it more carefully represented the performance of the cardio-respiratory system. Of course, body surface increases the demand without increasing the capacity for oxygen intake (22, 16). Therefore $\dot{V}o_2$ max. (LBM) unduly penalizes the thin individual. Researchers now feel that the standard $\dot{V}o_2$ max. is preferred in measuring the capacity to perform exhaustive work and $\dot{V}o_2$ max. (LBM) is preferred in measuring the performance of the respiratory-cardiovascular system (12, 16, 33, 8, 21).

Several parameters can contribute to an increase in $\dot{V}o_2$ max.; pulmonary ventilation, diffusion of O_2 from aveolar space, hemoglobin content, blood volume, efficiency of the mitochondria in transferring aerobic energy to the ATP-ADP machinery, and a loss in body weight (25, 34, 5, 8, 15, 26).

Loss in body weight is an inherent part of the sport of wrestling and its effects on $\dot{V}o_2$ max. should be noted. Several studies revealed that unless body weight is reduced in the course of training, seldom is the $\dot{V}o_2$ max. increased more than 10 to 15 percent when endurance is improving 60 to 300 percent (8, 26, 31, 35). Of course, the final denominator in calculating the $\dot{V}o_2$ max. is body weight. Therefore, if all other variables remain equal and body weight is reduced the $\dot{V}o_2$ max. will be increased proportionately. In the latter instance any interpretation regarding true training improvements would appear to be questionable.

CHAPTER III

RESEARCH METHODS

Subjects

A group of twelve male wrestlers 18 to 22 years of age were selected from the Michigan State University wrestling team. The wrestlers selected were deemed by the wrestling coach as those most likely to complete the wrestling season.

Methods

Heart rate, which was used as an indicator of approaching exhaustion, was recorded with a conventional electrocardiogram (EKG) apparatus with a visual read out of rate. The oxygen uptake was determined using the Douglas bag technique for the collection of expired gases and measurement of energy expenditure. Oxygen consumption was calculated as described by Consolozio, Johnson, and Pecora (11). The percent of oxygen and carbon dioxide in the expired air were measured by Beckman analyzers (E-2 and LB-15). The volume of expired air was measured by a Singer dry gas meter. The connecting tube between the respiratory valve (Otis-McKerrow) and the collection tubing was British corrugated, 1 inch inside diameter, 18 inches in length.

The system for the collection of expired air had a resistance equal to less than 2 ml. of water at flow rates in excess of 227 l/min. A motor driven treadmill with a speed capacity of 2-12 m.p.h. and grade ranging from 0 percent to 11.5 percent was used as the exercise instrument.[1]

Procedures

The subjects ran on two separate occasions; one week prior to the beginning of organized practice and again after 19 weeks of training. On each occasion the subjects ran until exhaustion. The first five minutes were submaximal and served as a warm up period. The expired air was collected during the fifth minute of the submaximal run. Serial 30 second samples were collected when it was judged by the investigator that the subject was within several minutes of exhaustion. Four factors were used by the investigator to judge the approach of exhaustion; heart rate, running coordination, skin color, and verbal responses from the subjects.

On each testing day the subjects were weighed prior to the run. This was used as the final denominator in calculating the $\dot{V}o_2$ max. Immediately after the weighing the subjects were prepared for the run. First, the electrodes were attached to the subjects as shown in Figures 1 and 2. Then the investigator explained the procedures to

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[1] A. R. Young Co., Indianapolis, Indiana.

the runner. The length of the run was determined by the limitations of each subject, but the procedures were standardized. The first five minutes were run at 6 m.p.h.--zero percent grade. After five minutes the speed and grade were raised to 7 m.p.h. and 2.5 percent, respectively. Thereafter, speed was held constant at 7 m.p.h., while the grade was increased by 2.5 percent every two minutes for the duration of the run.

All runs were performed at a barometric pressure of between 721 and 750 mmHg.

Determining the Maximum Oxygen Uptake

(1) Gas was pumped from the Douglas bag through the Beckman E-2 and LB-15 analyzers at 200 ml/min to obtain oxygen and carbon dioxide percentages in the bag.

(2) The initial dry gas meter reading was subtracted from the final meter reading after pumping the gas for each bag through, at a constant rate of flow. The meter difference was the uncorrected ventilation for that recorded collection period.

(3) The meter difference, corrected for the sample gas removed, was multiplied by the temperature-barometric pressure correction. This product was the corrected ventilation.

(4) The respiratory quotient and true oxygen values were determined as described by Consolozio, Johnson, and Pecora (11) using the Darling nomogram.

(5) The corrected ventilation was multiplied by the percentage of O_2 (true O_2) used and the time of the bag to convert the O_2 used into liters per minute values.

(6) The O_2 l/min was divided by the body weight (kg.) and by the lean body weight kg. The $\dot{V}o_2$ was reported in O_2 l/min/kg or O_2 ml/min/kg.

Body Composition

The lean body mass was calculated by estimating the percent fat from skinfold measures using the Durnin-Rahaman equations (17) by determining fat weight in pounds and then subtracting this value from the total body weight.

Statistical Analysis

The pre and post test data were analyzed using the t-test as described by Steel and Torrie (32).

CHAPTER IV

ANALYSIS OF THE DATA

The purpose of this study was to determine the effects of wrestling training on the $\dot{V}o_2$ max. of collegiate wrestlers. Several parameters; body weight, $\dot{V}o_2$ max./lean body mass (LBM) and endurance run (5 minute) were shown to be related and will be discussed as part of the analysis.

Previously, the methods used to collect the data were described and the related literature was reviewed. This chapter organizes the data and analyzes the results. After nineteen weeks of training, the results from the two $\dot{V}o_2$ max. tests and the related parameters were analyzed to determine if any differences could be attributed to the training. The data of each variable is presented graphically and the interpretation of these results are discussed as to their statistical significance.

Testing Results

Body Weight. The mean values and standard deviations of the body weights are presented in Figure 1. The results of the analysis of body weight data are shown in Table 1.

Table 1

	Mean Value	t
Test I	77.5 kg	-.679 NS
Test II	75.3 kg	
Difference	-2.2 kg	

The mean difference in body weight between the pre-test and post-test was not significant ($P > .05$).

<u>$\dot{V}o_2$ Endurance Run</u>. The mean values and standard deviation of the $\dot{V}o_2$ endurance run, which is the oxygen uptake obtained during the last minute of warm up are presented graphically in Figure 2. The results of the analysis for the endurance run are shown in Table 2.

Table 2

	Mean Value $\dot{V}o_2$ ml/kg/min	t
Pre-test	41.2	.048
Post-test	42.36	

The analysis of the endurance run data indicates that the difference between the pre-test and post-test was not significant. The wrestlers did not run more efficiently as a result of the training.

$\dot{V}o_2$ Max./LBM. The mean values and standard deviation of the $\dot{V}o_2$ max. run in which the $\dot{V}o_2$ max. value was divided by the lean body mass in kilograms are presented in Figure 3. The results of the analysis for the $\dot{V}o_2$ max./LBM are shown in Table 3.

Table 3

	Mean Value $\dot{V}o_2$ ml/kg. LBM/min	t
Pre-test	72.0	.042
Post-test	72.4	

The analysis of the $\dot{V}o_2$ max./LBM data indicates that the difference between the pre-test and post-test were not significant. The $\dot{V}o_2$ max./LBM was not improved by the training period.

$\dot{V}o_2$ Max. The mean values and standard deviations of the $\dot{V}o_2$ max. run, in which the $\dot{V}o_2$ max. values were divided by total body weight are presented graphically in Figure 4. The results of the analysis for the $\dot{V}o_2$ max. are shown in Table 4.

Table 4

	Mean Value $\dot{V}o_2$ ml/kg/min	t
Pre-test	60.9	1.06
Post-test	63.5	

The analysis of the $\dot{V}o_2$ max. data indicates that the difference between the pre-test and the post-test were not significant ($P > .05$). The maximal oxygen intake was not improved by the training period.

Discussion

The sport of wrestling is a competitive event which requires superior capacities in both aerobic and anaerobic processes. The training should obviously include these in combination. It was with this idea in mind that the investigator sought to find out what effects this type of training had on the $\dot{V}o_2$ max. and three related parameters. From the data presented, one may say that under the existing conditions, with this group of subjects, there were not significant changes in $\dot{V}o_2$ max. and the related parameters as a result of nineteen weeks of wrestling training.

One may wish to know if increasing the $\dot{V}o_2$ max. is of any value in developing wrestlers. Certainly a minimum $\dot{V}o_2$ max. would appear to be necessary. The minimum $\dot{V}o_2$ max. for wrestling has not yet been ascertained. Astrand and Saltin found that the Swedish National wrestling team's $\dot{V}o_2$ max. were low when put on a scale with other athletes (56 ml/kg/min). The wrestlers in the present study were higher than for the Swedish team but the post-test mean of 63.5 is not particularly high when compared with endurance athletes. An improvement had been anticipated. Clearly, the problem of the value of aerobic capacity in wrestling or the extent to which it should be trained for requires further investigation.

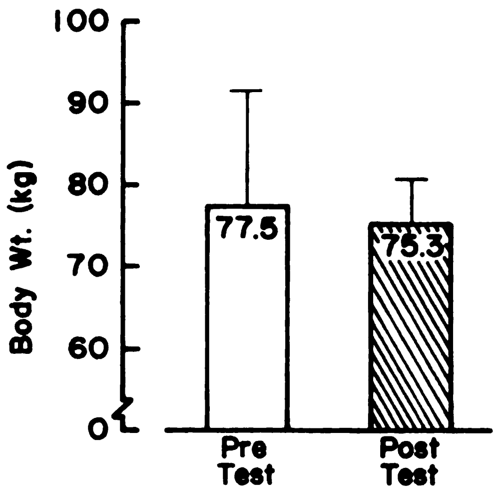

Fig. 1 Body Weight

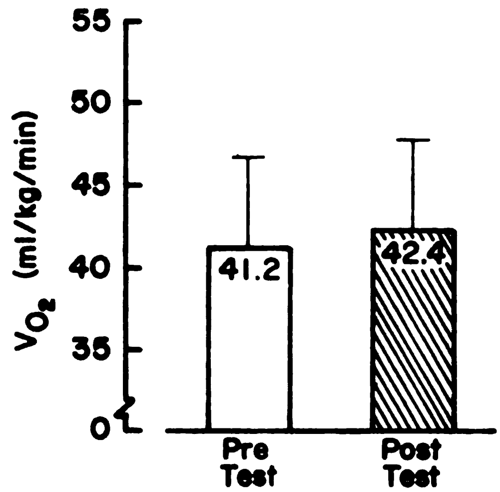

Fig. 2 O_2 Intake - Endurance Run

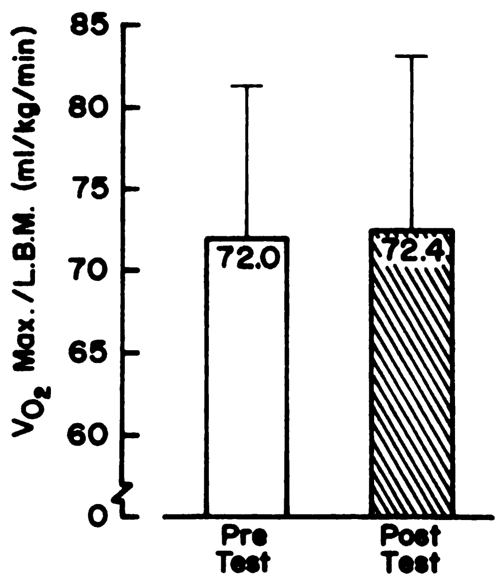

Fig. 3 Maximum O_2 Intake (Lean Body Mass)

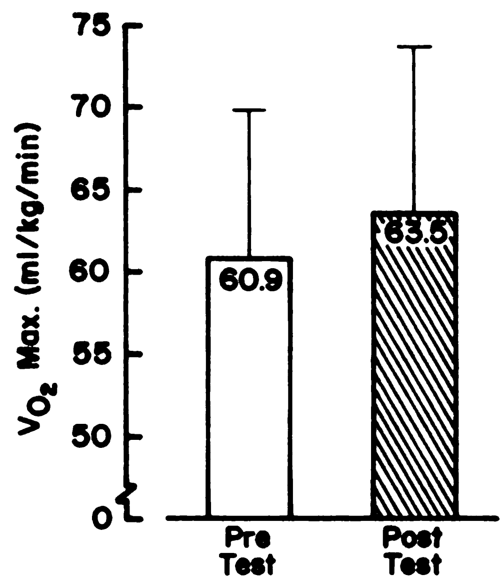

Fig. 4 Maximum O_2 Intake

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Twelve subjects were tested on two all out runs. The maximal oxygen intake per kilogram of body weight, maximal oxygen intake per kilogram lean body mass, oxygen intake during the last minute of the warm up period, and percentage of body fat were determined for each subject. A "t" test was used to determine the significance of the differences between the pre and post test data.

The pre-test was run one week prior to the start of wrestling practice and post-test after nineteen weeks of training. The testing consisted of an all-out run on a treadmill and body weight. The first five minutes the treadmill was set at 5 m.p.h. - zero percent grade, and served as a warm-up period. Following the warm-up period the speed and grade were increased to 7 m.p.h. and 2.5 percent grade respectively. The speed remained constant and the grade was increased 2.5 percent every two minutes until exhaustion.

Graphical presentation of the results showed a slight but insignificant increase in all variable means except body fat.

Conclusions

In university wrestlers nineteen weeks of the rigorous wrestling training described in the appendix did not significantly increase the $\dot{V}o_2$ max./kg body wt., $\dot{V}o_2$ max./LBM, the economy of running, or decrease body wt. (body fat).

Recommendations

Any further studies of this nature should be started with younger wrestlers and carried out for a longer period of time to determine the longitudinal effects of wrestling training on $\dot{V}o_2$ max./kg body wt., max. $\dot{V}o_2$/LBM, or max. $\dot{V}o_2$ endurance run, and body wt. (body fat).

Any further studies of this nature should use a larger number of subjects.

Any further studies of this nature should attempt to control the subjects' diet and activity outside of the practice area.

More research should be done to determine the minimum max. $\dot{V}o_2$/kg body wt. needed to compete at different levels of wrestling.

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APPENDICES

APPENDIX A

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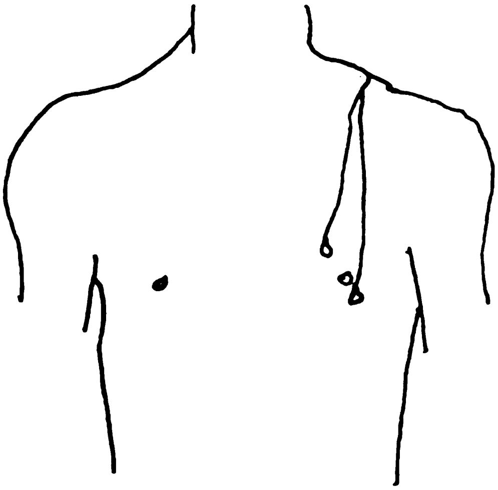

Figure 1

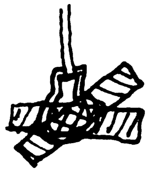

Figure 3

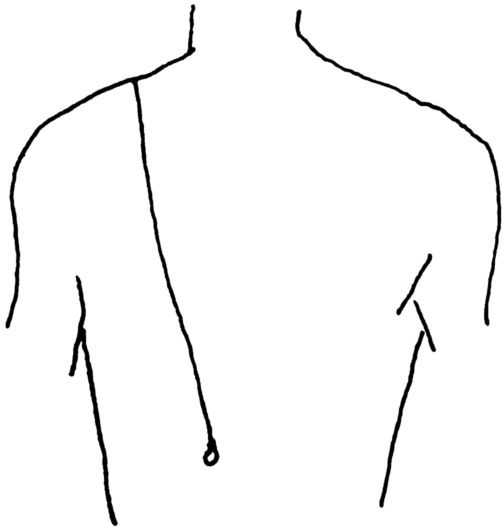

Figure 2

Attach Electrodes

(1) Cover the area where the electrodes will contact the subject's skin with tape.

(2) Spray the immediate area around the tape with Tuf Skin.

(3) Remove the tape.

(4) Place double faced circular tape around electrode cup.

(5) Place small amount of Redux (conducting cream) in the electrode cup.

(6) Stick the electrode to the subject and cover with adhesive tape (1" x ½"), Figure 3.

This has been found by the labs at Michigan State University to be the best way of attaching electrodes during prolonged exercise.

APPENDIX B

APPENDIX B

Training Program

The training program varied during the nineteen weeks of this study. The first two weeks served as a general conditioning program to prevent injuries. The next seventeen weeks phased out the conditioning exercises with more drilling (practicing skills without resistance) and hard wrestling.

The daily routine of the two conditioning weeks started with flexibility exercises stretching the different muscle groups of the body. This was followed by a one half mile jog and eleven strengthening exercises geared to strengthening the different muscle groups. The jogging and strengthening exercises were repeated three or four times depending on the day and the temperature.

Ensuing the two weeks of conditioning were seventeen weeks of wrestling training. The wrestling training got progressively harder for the next seven weeks until the first match. Following the first match the training was hard Monday, Tuesday, and Wednesday and tapered off Thursday with matches Friday and Saturday. This schedule continued until the second testing.

APPENDIX C

APPENDIX C

Original Data

Subject	ml-min/kg		body wt (kg)		5th minute $\dot{V}o_2$/kg		max $\dot{V}o_2$/LBM ml-min/kg	
	prior to season	after 19 week training	prior to season	after 19 week training	prior to season	after 19 week training	prior to season	after 19 week training
Don Rodgers	53	72.4	69.2	67.4	36.9	45.1	59.9	79.3
Scott Wickard	59.3	52.8	95	86.86	38.1	38.6	68.3	59.0
Dennis Brighton	56.5	66.9	65.2	63.6	45.4	44.4	69.3	77.7
Jeff Hersha	62.1	66.8	84.43	82.3	35.6	42.2	72.5	75.6
Rick Greene	60.2	74.4	80.98	75.4	void	void	76.9	85.8
Steve Rodriguez	73.6	75.6	74.8	71.06	40.7	42.6	84.7	84.2
Larry Avery	39.3	40.7	109.1	105.5	36.7	33.5	54.3	51.9
Tim Prior	64.2	63.4	80.8	80.21	40.4	42.6	78.1	78.1
Armand Ternak	71.7	68.1	61.7	63.52	42.1	40.4	83.4	75.8
Pat Milkovich	63	63.7	64	59	void	void	69.4	69
Mike Brook	61.4	65.3	76.76	79.2	41.6	44.3	69.5	73.4
Mike Owens	67	52.5	67.6	69.2	54.5	49.9	77.4	59
MEAN	60.94	63.55	77.46	75.27	41.2	42.36	71.975	72.4