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ABSTRACT

The use of various physiological tests and measurements accurately predicts the performance ratings of female athletes. A study involving 180 female intercollegiate volleyball players, 142 female intercollegiate basketball players, and 115 female college-age nonathletes yielded a set of statistical differentials concerning arm length, lean weight ratio to fat weight ratio, leg strength, and running speed. On the basis of the statistical data alone, researchers were able to successfully classify the test subjects into the appropriate category of volleyball player, basketball player, or nonathlete. Tests of this kind are of interest to sports personnel for use in recruitment and training decision-making. (LH)

PREDICTION IN SPORT: THEORIES & APPLICATIONS

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PREDICTION IN SPORT: THEORIES & APPLICATIONS

Prediction and, hopefully, explanation are the ultimate outcomes of scientific theory. Coaches normally use personal experience, expert opinion or insight to predict performance capabilities. They use empirical observations to explain how they selected players for the team or how they diagnosed player weaknesses. These subjectively based decisions are often valid, however they do not meet the criteria of quantification or accountability. Since they are not based in actual data they are not directly related to scientific theory.

Statistical techniques of inference serve as a link between scientific theories (hypotheses) and the actual data. These techniques, when properly applied, allow researchers to glean information from accumulated data about the relationships among variables. This information forms the basis for the theory in question and allows the researcher (and eventually the coach) in many cases to explain the natural phenomena - in actuality it allows one to PREDICT.

Whereas explanation is the ultimate aim of scientific inquiry, prediction is a sufficient condition to allow researchers to develop theory. Recently, several physical education researchers have conducted studies aimed at prediction in sport and physical education (see attached list of references). The thrust of these studies involves finding a set of variables that predicts some aspect of athletic performance. The basis of this prediction is the existence of relationships between some criterion of athletic performance and predictor variables of basic motor abilities, anthropometric characteristics, psychological factors, etc.

Preliminary Measurement Aspects

From a measurement standpoint prediction is concerned with accounting for maximum variation in the criterion measure. Familiar examples in sport research are predicting Max VO_2 from distance runs and predicting percent body fat from skinfolds and/or anthropometric measures. Both of these examples have ratio variables as the criterion measure, therefore they are well suited to multiple regression analysis. However, in many cases the criterion variable is nominal in scale. That is, you either are or you are not. For example, you are a back in football or a lineman, a varsity athlete or a non-varsity athlete, etc. In the case where the criterion measure is nominal in scale, the appropriate statistical technique is discriminant analysis. We will eventually return to discriminant analysis.

However, we would first like to discuss some simpler statistical techniques that may be used before one attempts to utilize the more powerful discriminant technique. Perhaps the utilization of performance profiles is a technique that nearly anyone who is familiar with simple descriptive statistics can perform. Data are gathered on various independent variables and displayed in some logical way, such as centile charts. The mean for each group is determined for the various intact groups and plotted on the centile chart (for example) and one makes decisions whether or not there are trends in the data. Whether the decision is one of selection, classification or simply diagnosis the use of performance profiles is very helpful in dealing with this type of information.

Construction of Performance Profiles

Performance profiles are data sheets that depict performance levels on a number of tests for some group of subjects. An example of a performance profile in shown in Figure 1. The tests were selected through discriminant analysis. There are several ways in which the profile sheets can be developed.

INSERT FIGURE 1 ABOUT HERE

The use of percentiles in developing performance profiles is the most valid and stable way of presenting data of this type. The procedure for using percentiles is discussed in detail by Baumgartner and Jackson (1975). Percentiles are also useful because of the ease with which they can be interpreted.

However, there are some problems associated with the use of percentiles. In order to be used validly the percentiles should be based on well over 100 cases. In many instances this is impractical.

Another problem is also associated with centile charts. In some variable, no distinct score may be associated with a given percentile. The larger the sample the smaller the chance of this problem.

Also, percentiles represent ordinal data. That is, the distance betwen selected percentle intervals may not be represented by equal intervals in the test variables. For example, the difference between the 40th and 50th percentiles for the 20 yard sprint is .4 sec., whereas the difference between the 70th and 80th percentile is .5 sec. Even with these problems, percentile norms are the best. Whenever possible, profiles should be developed using this technique.

However, if it is not possible to obtain a large number of cases it is possible to develop profiles using a standard score basis (Z-score). A Z-score is a score that is standardized in relation to the mean and variability of the test involved. The use of Z-scores is also described by Baumgartner and Jackson (1975). As example of Z-score profiles is presented in

Figure 2. The data for this table were taken from a study by Disch, Ward and Foreman (1979) on a sample of female track performers. The data are based on 41 cases - too few to develop meaningful percentiles. The profile was developed about the mean Z-score (0.0) and an arbitrarily chosen interval (0.2). The profile was then calculated for scores ranging from -2.0 to +2.0. One virtue of this method is that there are equal differences between Z-score intervals and test score intervals. For example, the test score distance between Z-score of 0.6 to 0.8 is the same as the distance between Z-score of -1.2 to -1.4. Another advantage is that they can be assumed to be represented by specific percentages of the normal curve. This aids in interpretation.

The major drawback related to the Z-score method is the fact that scores on the chart may exceed the range of scores actually achieved. In some cases, negative numbers could be calculated for such things as percent body fat or number of pull ups. The way that problems of this nature are handled is to convert these values to "zero" measures.

INSERT FIGURE 2 ABOUT HERE

The last method of construction is to include score values that run the range of the data and to represent scores at arbitrarily chosen intervals. This is the simplest way, however it provides the least amount of information. An example of this method is presented in Figure 3. Fifteen national class female volleyball players were tested. The range of scores that they achieved on the various tests is provided. This alleviates the problem of exceeding the actual range of the scores and it is the most simple mathematically. However, little information is provided about percentage rankings or interval standings. This technique is suggested when a small number of subjects is available or as a "quick and dirty" method of examining the data.

INSERT FIGURE 3 ABOUT HERE

Statistical Factors

Another statistical application is the calculation of univariate F tests on the various "predictor" variables. The categories of the nominal criterion variable are used as the fixed levels of the independent measure in the analysis of variance and the independent (predictor) variables from the prediction model become the dependent measures in this design. This in essence is an approach to discriminant analysis. Certainly one may question the utilization of multiple F tests with many dependent variables. However, recall that since our intention is to talk about discrimination as such, we need not be concerned with the "overlap" among the various dependent variables in the ANOVA model. Additionally, and more statistically appropriate, one could calculate a Multivariate F test (MANOVA). It should be noted that if there is a significant MANOVA result, one will also obtain a significant discriminant function. However, the use of MANOVA leads us back to the more complex statistical techniques!

When conducting statistical analyses for performance based data the design considerations are basically sample size and composition and test selection. Prediction in sport is usually very task specific (i.e., very homogeneous, often highly skilled groups are examined to determine what anthropometric, physiological or motor performance factors differentiate them from other groups). These other groups may be similarly homogeneous and highly skilled (in which case the question becomes one of classification) or they may be of differing skill levels (yielding a question of selection). In either case the size of the sample is often small to moderate and the randomness of the group is lacking by its inherent nature - a homogeneous cluster.

With these limitations in mind, tests must be selected diligently to meet rigid standards of reliability and sound gauges of criterion related validity. If tests are selected in this manner the possibility of taking advantage of unique elements within the specific groups tested is minimized.

Certain questions of reliability and validity should be considered. The reliability of many of the variables often selected for these types of analyses is best established through the use of intraclass procedures. This means that multiple trials of these measures must be administered which increases the length of testing.

In selection and classification questions, techniques or predictive validity are used. However, in some classification questions and in diagnostic situations the question becomes one of concurrent validity. Although differentiating between predictive and concurrent validity does nothing to alter the statistical analysis, it may alter procedures for data collection and interpretation.

The statistical procedures designed to analyze questions of criterion related validity are multiple regression and multiple discriminant analysis. Regression analysis is a widely used tool in prediction studies, however, it assumes the use of a continuously (ratio or interval) scaled criterion measure which is difficult to achieve in many sport studies. In many sport prediction situations the criterion measures are categorical (e.g., Varsity-JV or starter-non-starter). Also, athletes can be classified according to sports or positions or events within a sport. These situations also deal with categorical dependent measures (cases in which discrimant analysis should be used).

Selection of the Predictor Variables

If the dependent variable in the prediction model is nominal in scale the interpretation is quite simplified. You simply are comparing results from various intact groups. The predictor varibles are, however, quite important and should be determined from previous research, theory, and logical validity. It is most appropriate to choose independent variables that are unrelated to each other as in regression studies. That is they have little in common. The reasons for this are several: certainly it is a waste of time and effort to measure the same thing "twice". Also, if the correlation between the predictor variables is relatively high, the addition of a variable which is related to another independent variable will not result in accounting for much variation in the criterion variable; and finally, if several variables are correlated the problems of colinearity must be considered.

Various guidelines are given with regard to the number of subjects that one should have when conducting the various analyses. If one were to consider the group of people that is to be tested to represent the population of people, the number of subjects would irrelevant. However, one would usually like to generalize from the sample to the population "from which the sample was drawn". A lower bound for the number of subjects is two times the number of variables plus one. A more liberal estimate is (p times (p+3))/2 where p is the number of variables involved. Both of these estimates apply to the number of people within each group.

We in physical education are in a unique situation in that many of the variables that we measure are highly reliable. Without a doubt, educators and psychologists would be extremely happy to obtain measures with the reliability coefficients that we often obtain. Prior to obtaining the various measures for predictive purposes, one should consider the validity and the feasibility of obtaining the measures. For example, Jackson and Pollock (1976) have indicated that girth anthropometric measures are multidimensional in structure. Thus, if one simply wanted to use measures of body fat, it would be most appropriate (valid) to obtain skinfold measures and not girths and lengths. However, if body size is a relevant variable, one should consider the use of skinfolds, girths and lengths as predictor variables. (Again, realize that caution should be used to not obtain variables that are correlated). With regard to feasibility, one should consider whether or not it is necessary to go to extra expense and work to obtain a "true" measure of percent body fat or simply estimate it as was suggested earlier. Such decisions are especially important when data are to be obtained on a large number of subjects.

Selection of the Criterion Measure

As in all prediction studies, the selection of the criterion measure is of extreme importance. If the criterion measure is not valid then one is simply predicting a variable which in and of itself is not a truthful measure. As stated earlier, when the dependent variable is nominal in scale, the criterion is pretty well specified.

As in any predictive situation, one must be concerned with the error involved in the prediction. When the dependent variable is ratio in scale, the error is referred to as the standard error of prediction or simply the standard error.

In regard to discriminant analysis perhaps it would be better to refer to percent of correctly classified subjects as a measure of the error in the model. In a real sense one gets into the frame of considering "false positives" and "false negatives" in prediction. This is particularly true when one considers the potential for utilizing these techniques for predicting team success or team selection. In such cases, much like in the type one and type two error considerations of ANOVA, one has to make a decision with regard to which type of error is more significant to make with regard to one's particular predictive process.

For these reasons multiple discriminant analysis is best suited to attack these kinds of questions. Oftentimes in the past, researchers have artificially created ratings, purportedly on an interval scale, to allow them to use regression techniques. This technique is often plagued with measurement problems and is altogether unnecessary.

Also much of the information important to prediction related questions is readily provided by discriminant programs. Not only is the significance of the discrimination battery tested, but also the contribution of the variable(s) (both simply and in union) is examined. Also, information about specific cases is provided in a more amenable form than in regression studies. Discriminant analysis will be examined in more detail in the examples that follow.

In closing this section let me state that the results of such statistical analyses may be perceived by many as too involved. In a sense this may be somewhat true. Coaches usually are fairly competent in selecting players that will be successful in the future. However, the utilization of these statistical techniques helps provide us with more concrete evidence for decision making purposes. The inclusion of such data from various years will help to provide the researcher as well as the coach with benchmark or baseline data from which to make decisions about the future performance of athletes.

In conclusion there are several cautions which should be noted. First, the results are innately dependent upon the validity of the criterion. Second, the results are often sample specific - generalizability is not suggested. And third, only a portion of the total variance of performance is accounted for by these prediction studies. Ultimate performance is based upon an interaction of these findings with coaching considerations - practices, psychology, etc. The primary virtue of prediction in sport is that it yields concrete information upon which theories can be developed.

EXAMPLES

The data for our examples come from measurements obtained on various groups of athlete and non-athlete college women. The athlete groups are two in number: intercollegiate volleyball players and intercollegiate basketball players. The non-athletes were college age women enrolled in physical education service classes. While some may have been high school athletes, they were not engaged in any intercollegiate athletics. Informed consent was obtained from all subjects. The original sample of women consisted of 180 volleyball players, 142 basketball players, and 115 non-athletes.

Example #1

Our first example deals with predicting women into athlete versus non-athlete groups based upon physical performance and anthropometric variables. The three identified groups are 1) non-PE majors enrolled in PE service classes 2) women intercollegiate basketball players and 3) women intercollegiate volleyball players.

One hundred-ten women were in each group. These subjects were randomly selected from the larger samples of similar subjects. The variables (listed in Table 1) measured were thought to be representative of three demensions; body size, speed, and strength. Fat weight and lean weight were determined from a multiple regression equation using skinfolds and age (Jackson, Pollock & Ward, 1978). Anthropometric measures were obtained according to Behnke and Wilmore (1974). Ten yard sprint was electronically timed to .001 second. Bench and leg press means were obtained on Cybex isokinetic machines (Lumex Corp., N.Y.). All measures had reported reliabilities greater than .90. Our first questions involve the possibility of predicting athletic participation based upon the measures taken. Thus our groups become two in number: 1) non-participants and 2) participants (consisting of basketball and volleyball players). Based upon the univariate ANOVA (Table 2) results, one sees that the groups differed significantly on each variable. However, the discriminant analysis results provide us with a better picture of how the groups differ. Standardized discriminant weights are presented in Table 3. The variables with the highest discriminant weights are lean weight, 10 yard sprint time and arm length. (Note that only one discriminant function is obtained because we have 2 groups). Women athletes tend to have longer arms, a higher lean body weight and faster 10 yard sprint times than non-participants. Based upon the discriminant function scores, we were able to correctly classify 93% of the subjects. Table 4 shows the results. Note that while 11% of the non-participants were classified as participants, only 5% of the participants were classified as non-participants. That is, 11% of non-participants evidenced characteristics of the women athlete while 5% of the women athletes evidenced characteristics of the non-athletes. Thus, without any evidence of skill level we are able to correctly "predict" group classification for a large proportion of our subjects (93%). The prediction results indicate that our data help us to better determine "who can't than "who can" be successful team members. That is, some people who can are identified as possible unsuccesses. However, those who are predicted to be unsuccessful probably do not have the characteristics with which to be successful. The 5 percent athletes who were classified as non-participants can be identified as "false negatives". The 11 percent of non-athletes classified as athletes can be identified as "false positives". It would be of interest to further investigate those two classifications of people. Cross validation on the remaining sample of women should also be attempted.

Example #2

Our second example is an extension of the previous one. We have now delimited ourselves to the two athletic groups (women intercollegiate volleyball players and women intercollegiate basketball players). The univariate results seen in Table 5 show somewhat different results than earlier.

The variables which differ significantly for our two groups are 10 yard sprint, arm length, biiliac width, and isokinetic leg and bench press strength. The discriminant analysis results in Table 6 indicate that arm length and leg press are variables that differ between the groups when other variables are controlled. The basketball women have longer arms and have greater leg strength then the volleyball players. Based upon the characteristics of the women, we are able to correctly classify 86% of the women athletes into the correct activity membership. This is shown in Table 7. Of the 110 women in each group only 15 volleyball players were classified as basketball players and only 16 basketball players were classified as volleyball players. One might say that the incorrectly classified players have the characteristics of women from the opposite activity.

Example #3

Our third example is a delimitation of the previous one. In this case, our discriminant group is volleyball team membership (Sixteen Teams). Because the number of subjects on a team was about 12, we have limited our variables to six. They are listed in Table 8 (10 yard dash, height, lean body weight, fat weight, and isokinetic leg and bench press). In this example, our intent is not as much to predict team membership but to plot the group centroids in the discriminant space in order to determine if there is a relationship between the discriminant score and team record for the volleyball teams analyzed. The teams had competed in a bracketed round robin tournament. Univariate ANOVA results are seen in Table 9. The resultant discriminant analysis indicates two significant functions. They are presented in Table 9. The resultant discriminant analysis indicates two significant discriminant functions. They are presented in Table 10. The first dimension separates teams who are tall, run fast and have a low fat weight from teams with opposite characteristics. The second dimension separates teams who are strong on the bench press and low in lean body weight from those with opposite characteristics. The team centroids for the two significant discriminant functions are presented in Figure 4. Team records are designated with the following symbols: 4-0 (A); 3-1 (B); 2-2 (C); 1-3 (D); 0-4 (E). As indicated, the teams with 4-0 records are all highest on dimension I. The 0-4 teams are all at or below the mean on the function. The interpretation of the second discriminant function is not nearly as clear. No general conclusion can be drawn regarding team record and the score on the second function. It would appear that teams with better records tend to be taller, carry less fat weight and run faster then teams with poorer records. Perhaps this is an indication that if one were attempting to predict team success, modifications in recruiting and training regimes are appropriate for the poorer teams.

In conclusion, recall that we were attempting to classify subjects into the correct group membership based upon some performance variables. As our examples show, it may be possible to correctly predict team membership with a great deal of success. Of course this depends upon the theory upon which the data are based. We are tempted to advocate the calculation of discriminant scores for prospective athletes. However, we realize that this will not likely be done. However, as a result of our investigation we are better able to identify those variables which will perhaps best serve as marker variables for identification of potentially successful team members.

We now have concrete evidence upon which to make decisions regarding recruitment and training. In each case we were able to discern variables (and/or dimensions) which characterized our various intact groups. These variables and/or dimensions can provide the coach with valuable information when making decisions regarding the predicted success of an individual or a team.

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TABLE 1

MEANS FOR VARIABLES MEASURED

Variable	Non Athletes	Volleyball Players	Basketball Players	Total
Fat weight (Kg)	11.70	13.31	13.45	12.82
Lean weight (Kg)	42.84	51.76	52.25	48.95
Height (Cm)	161.66	170.38	171.53	167.86
Sitting Height (Cm)	84.01	86.58	86.68	85.76
Arm length (Cm)	52.40	56.57	58.83	55.93
Biacromium (Cm)	35.23	37.87	37.64	36.91
Biiliac (Cm)	27.37	28.16	29.09	28.21
10 yard sprint (sec)	1.880	1.681	1.724	1.762
Bench Press (Kg)	30.59	40.59	42.48	38.52
Leg Press (Kg)	128.45	141.42	179.65	149.84

TABLE 2

UNIVARIATE F VALUES FOR NON-ATHLETE VS ATHLETES

VARIABLE	F
Fat Weight	13.71
Lean Weight	251.95
Height	146.82
Sitting Height	37.10
Arm Length	205.66
Biacromium	127.94
Biiliac	29.02
10 Yard Sprint	186.00
Bench Press	107.56
Leg Press	62.91

df = 1,328
Critical Value $p < .01 = 6.70$

TABLE 3

STANDARDIZED DISCRIMINANT WEIGHTS NON-ATHLETES VS ATHLETES

VARIABLE	
Fat Weight	.05
Lean Weight	.41
Height	-.12
Sitting Height	-.03
Arm Length	.41
Biacromium	.04
Biiliac	-.03
10 Yard Sprint	-.49
Bench Press	.05
Leg Press	-.02

TABLE 4

PREDICTION RESULTS NON-ATHLETES VS ATHLETES

Actual Group	Predicted Group	
	Non Athlete	Athlete
Non-Athletes (N=110)	98 (89%)[a]	12 (11%)
Athlete (N=220)	11 (5%)	209 (95%)

[a]Percent of cases

TABLE 5

UNIVARIATE F-VALUES FOR VOLLEYBALL VS BASKETBALL PLAYERS

Variable	F
Fat Weight	.07
Lean Weight	.48
Height	1.58
Sitting Height	.04
Arm Length	29.87
Biacromium	.92
Biiliac	16.80
10 Yard Sprint	11.05
Bench Press	7.24
Leg Press	80.68

df = 1 and 218
Critical value $p < .05 = 3.89$; $p < .01 = 6.76$

TABLE 6

STANDARDIZED DISCRIMINANT WEIGHTS VOLLEYBALL VS BASKETBALL PLAYERS

Variable	
Fat Weight	.15
Lean Weight	.30
Height	.38
Sitting Height	-.03
Arm Length	-.75
Biacromium	.19
Biiliac	-.24
10 Yard Sprint	-.36
Bench Press	-.11
Leg Press	-.66

TABLE 7

PREDICTION RESULTS VOLLEYBALL VS BASKETBALL

Actual Group	Predicted Group Volleyball	Basketball
Volleyball (N = 110)	95 (86%)[a]	15 (14%)
Basketball (N = 110)	16 (15%)	94 (86%)

[a]Percent of cases

TABLE 8

DELIMITED VARIABLES

Fat Weight
Lean Weight
Height
10 Yard Sprint
Bench Press
Leg Press

TABLE 9

Univariate F-Values For Volleyball Teams

Variable	F
Fat Weight	3.32
Lean Weight	1.18
Height	2.39
10 Yard Sprint	4.04
Bench Press	3.34
Leg Press	1.86

df = 15 and 142
Critical values $p < .05 = 1.73$; $p < .01 = 2.15$

TABLE 10

Standardized Discriminant Weights Volleyball Teams

Variable	Function 1	Function 2
Fat Weight	-.60	-.36
Lean Weight	.04	.76
Height	.37	-.38
10 Yard Sprint	-.43	-.33
Bench Press	.33	-1.01
Leg Press	-.05	-.11

Figure 1

Centiles for strength, speed, and anthropometric characteristics of college volleyball players

Centile	Weight (kg)	Height (cm)	Biacromial (cm)	Biilac (cm)	20 Yard Sprint (sec)	Bench[a] Press (lbs)	Leg[a] Press (lbs)	Sum of[b] Skin-folds	Body[c] Fat %	Centile
95	79.1	180.1	40.2	30.5	2.81	126	410	31.8	15.7	95
90	74.5	178.2	39.8	30.2	2.86	118	386	36.1	17.0	90
85	73.2	176.0	39.2	29.9	2.88	114	373	38.9	17.8	85
80	71.4	174.6	39.1	29.5	2.90	107	366	41.3	18.5	80
75	70.0	173.4	38.7	29.4	2.93	104	358	43.3	19.1	75
70	68.6	172.4	38.6	29.1	2.96	98	347	45.0	19.7	70
	67.3	171.4	38.4	28.9	2.98	94	340	46.5	20.1	65
60	65.5	170.7	38.1	28.6	3.00	90	331	48.2	20.6	60
55	64.5	170.2	37.9	28.3	3.01	88	324	49.6	21.0	55
50	63.6	169.5	37.7	28.0	3.03	84	316	51.1	21.5	50
45	62.7	169.1	37.5	27.8	3.04	82	311	52.6	22.0	45
40	62.[illegible]	168.4	37.3	27.7	3.07	81	305	54.0	22.4	40
35	61.4	168.1	37.1	27.5	3.08	79	294	55.7	22.9	35
30	60.5	167.1	36.8	27.2	3.11	76	290	57.2	23.3	30
25	59.1	165.7	36.6	27.0	3.14	74	283	59.0	23.9	25
20	58.2	164.7	36.4	26.7	3.17	72	271	61.0	24.5	20
15	57.3	163.3	36.2	26.4	3.20	69	259	63.3	25.2	15
10	56.4	162.0	35.8	26.2	3.27	67	239	66.1	26.0	10
5	53.6	160.6	35.5	25.7	3.33	63	215	70.5	27.4	5

[a] Isokinetic strength measured on Cybex Power Bench and Leg Press.

[b] Tricep+suprailiac+thigh

[c] Percent fat = (4.95/B.D. -4.5) x 100. (Siri, 1956)

Figure 2

Performance Profiles for Female Track Athletes*

Z Score Equivalent	Weight	Lean Body Weight	Percent Body Fat	Sum of Skinfolds	Visual Reaction Time	Vertical Jump	Velocity2 5-10 yds (Interval Time)	Velocity 8 35-40 yds (Interval Time)
2.0	186.88	140.88	9.47	40.53	.189	24.27	20.80 (.721)	28.25 (.531)
1.8	181.03	137.15	10.37	49.54	.194	23.63	20.59 (.729)	27.80 (.540)
1.6	175.18	133.42	11.28	58.55	.199	22.99	20.38 (.736)	27.39 (.548)
1.4	169.32	129.70	12.18	67.57	.204	22.35	20.17 (.744)	26.99 (.556)
1.2	163.47	125.97	13.08	76.58	.210	21.71	19.96 (.752)	26.59 (.564)
1.0	157.61	122.24	13.99	85.59	.215	21.07	19.75 (.760)	26.18 (.573)
0.8	151.76	118.52	14.89	94.61	.220	20.42	19.54 (.768)	25.78 (.582)
0.6	145.90	114.79	15.80	103.62	.225	19.78	19.33 (.777)	25.37 (.591)
0.4	140.05	111.06	16.70	112.63	.231	19.14	19.12 (.785)	24.97 (.601)
0.2	134.19	107.34	17.61	121.65	.236	18.50	18.91 (.793)	24.57 (.611)
0.0	128.34	103.61	18.51	130.66	.241	17.86	18.71 (.802)	24.16 (.621)
-0.2	122.49	99.88	19.41	139.67	.246	17.22	18.50 (.811)	23.76 (.631)
-0.4	116.63	96.16	20.32	148.68	.251	16.58	18.29 (.820)	23.36 (.642)
-0.6	110.78	92.43	21.22	157.70	.257	15.94	18.08 (.830)	22.95 (.654)
-0.8	104.92	88.70	22.13	166.71	.262	15.30	17.87 (.839)	22.55 (.665)
-1.0	99.07	84.98	23.03	175.72	.267	14.65	17.66 (.849)	22.14 (.678)
-1.2	93.21	81.25	23.94	184.74	.272	14.01	17.45 (.860)	21.74 (.690)
-1.4	87.36	77.52	24.84	193.75	.278	13.37	17.24 (.870)	21.34 (.703)
-1.6	81.50	73.80	25.74	202.76	.283	12.73	17.03 (.881)	20.93 (.717)
-1.8	75.65	70.07	26.65	211.78	.288	12.09	16.83 (.891)	20.53 (.731)
-2.0	69.80	66.34	27.55	220.79	.293	11.45	16.62 (.902)	20.12 (.746)

Scores represent standard score transformations for the various tests.

(1) Distance Runners ▬▬ (2) Sprinter/Jumpers ...... (3) Throwers ═══

(4) Subject No. 7 - - - -

Figure 3

VOLLEYBALL PERFORMANCE DATA

					KN. EXT 90°		KN. EXT 165°		AK. PL. FL.	
AGE	HEIGHT	WEIGHT	REACH	% BF	LL	RL	LL	RL	LL	RL
					107					
			98.5		105	121.5	90			
			98		103	119	88			
365			97.5		101	116.5	86	75.5	236	236
360			97		99	114	84	74	232	232
355		179	96.5		97	111.5	82	72.5	228	228
350	77	177	96		95	109	80	71	224	224
345		175	95.5		93	106.5	78	69.5	220	220
340	76	173	95	16.1	91	104	76	68	216	216
335		171	94.5	16.3	89	101.5	74	66.5	212	212
330	75	169	94	16.5	87	99	72	65	208	208
325		167	93.5	16.7	85	96.5	70	63.5	204	204
320	74	165	93	16.9	83	94	68	62	200	200
315		163	92.5	17.1	81	91.5	66	60.5	196	196
310	73	161	92	17.3	79	89	64	59	192	192
305		159	91.5	17.5	77	86.5	62	57.5	188	188
300	72	157	91	17.7	75	84	60	56	184	184
295		155	90.5	17.9	73	81.5	58	54.5	180	180
290	71	153	90	18.1	71	79	56	53	176	176
285		151	89.5	18.3	69	76.5	54	51.5	172	172
280	70	149	89	18.5	67	74	52	50	168	168
275		147	88.5	18.7	65	71.5	50	48.5	164	164
270	69	145	88	18.9	63	69	48	47	160	160
265		143	87.5	19.1	61	66.5	46	45.5	156	156
260	68	141	87	19.3	59	64	44	44	152	152
255		139	86.5	19.5	57	61.5	42	42.5	148	148
250	67	137	86	19.7	55	59	40	41	144	144
245		135	85.5	19.9	53	56.5	38	39.5	140	140
240	66	133	85	20.1	51	54	36	38	136	136
235		131	84.5	20.3	49	51.5	34	36.5	132	132
230	65		84	20.5	47	49	32	35	128	128
225			83.5	20.7	45	46.5	30	33.5	124	124
220				20.9		44	28	32	120	120
				21.1		41.5	26	30.5	116	116
				21.3					112	112
				21.5					108	108
				21.7					104	104
									100	100
										96

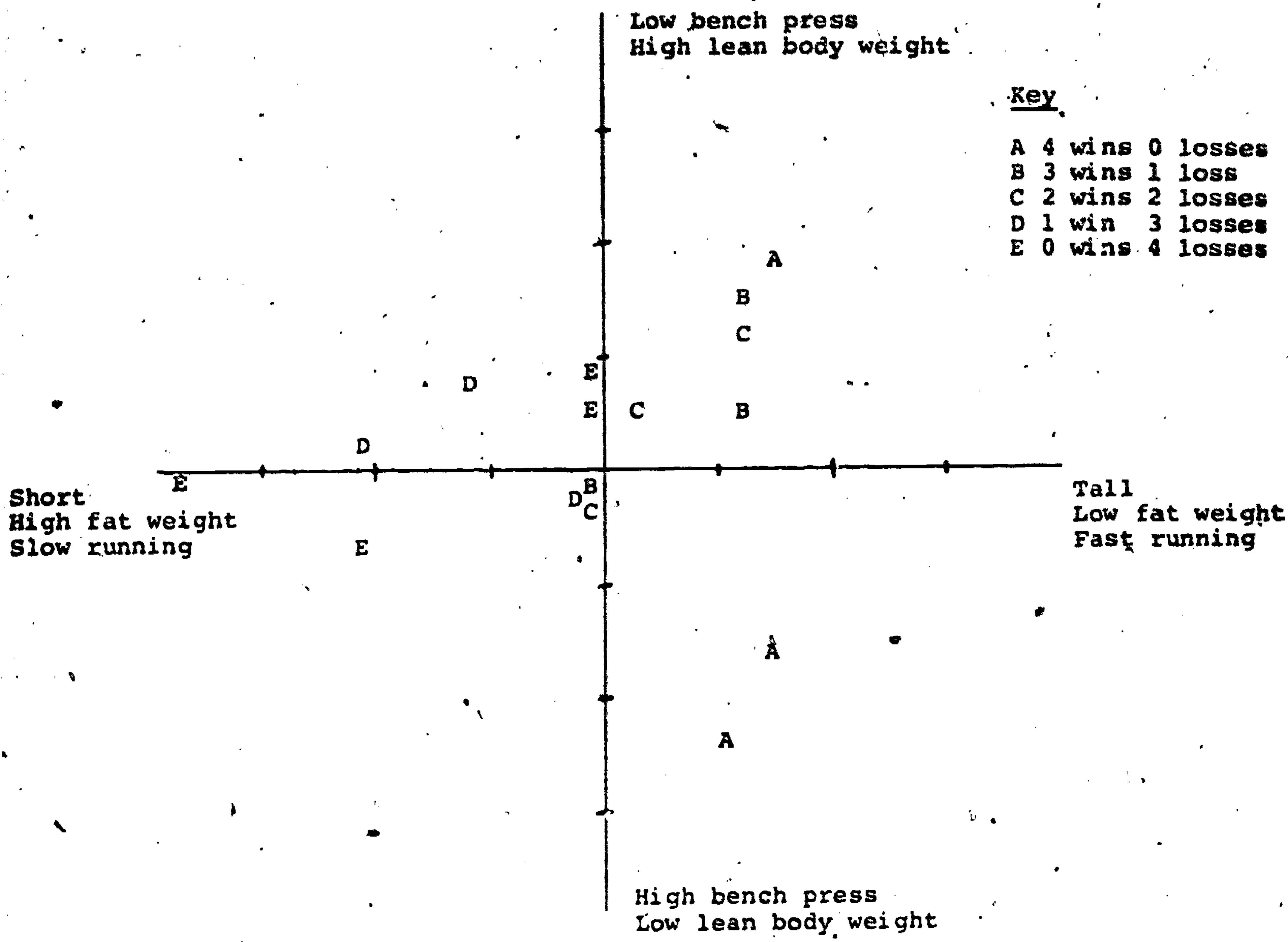

Figure 4

Plot of team centroids in two discriminant space.