Semmelweis University
Doctoral School of Education and Sport Sciences

COMPETITION TRAINING AND COMPETITIVE PREPARATION OF NATIONAL TEAM LEVEL FENCERS

Abstract of Ph.D. thesis
by László Szepesi

Supervisor: Professor Endre Rigler Ph. D.

Budapest, 2003.

Quantitative factors of the competitive and training work applied in the preparation of 29 French elite swordsmen were analysed. In addition to the training log the study made use of the official records of the seven World Cup contests of selection and further eight competitions of preparation in the years 1982 through 1992. After the 12 to 14 weeks of basic conditioning two weekly practice contests supplemented the 14 to 16 competitions of every year; data on these were included in the database under analysis. The main purpose of the analysis was to clarify which of the training stress indicators had the strongest influence on, or explanatory power for, the results achieved at the world championships or Olympic games. As shown by the descriptive and regression statistics, 1) the members of the national team differed from the second ranks of elite sabre fencers in all but one measure; 2) as for the performance at the Olympic games or world championships, neither the usefulness, nor the predictive power of the contests of selection grew as the season approached its end; 3) though being apparently merely quantitative, the training stress indicators exerted a great deal of indirect influence, some of which developed after a considerable time lag and/or were conflicting. For these reasons 4) a multiple and complex approach to the factors of performance is not merely justifiable, but may reveal relationships that formerly have gone unnoticed. In designing the competitive and training work one has to be aware of all these possibilities.

1. The period under study and the details of athletic preparation

The period studied lasted from 1982 till 1992. The training season began around the 20th of September and usually ended with either the world championship or the Games in the middle of July. Note the exceptions: the Los Angeles Games were in early August in 1984 as were the Barcelona Games in 1992, while the 1988 Games in Seoul took place at the end of September. It was almost as a last resort before dissolving the French national team of sabre because of their long record of failure at the world championships and Olympic games that I was invited to become their coach. I considered the lack of success being due to an insufficient amount of competitive practice and training work so I reshaped their competitive and training regimen as follows.

I divided the season into three periods of 14 weeks each of which had a specific objective. In the first half of the first period of 14 weeks the fencers had to perform "classical" conditioning exercise: developing strength, runs, playing exercises and ball games. Then the share of fencing work was gradually increased, rope skipping, conventional individual and paired training, etc. Fencing work in the strict sense only began in the 7th or 8th week by individual lessons, practice bouts, systematic and free fencing. The first World Cup of the season in Nancy was the closing event of the first period of basic conditioning.

The second period of 14 weeks (from January until April) was subdivided by the World Cups in Moscow, Budapest (Hungaria Cup), Hannover and New York. This period of preparation served the gauging of potential adversaries and the development of new tactical exercises and tasks. During this time tactical and technical elements were practised in individual lessons and thematic bout exercises. This sort of work was complemented by special fencing tasks performed 3 meters under water in the swimming pool. These represented a quite particular physiological stress of training in addition to their role in stabilizing specific movements.

The third and last period of 14 weeks was devoted to finalizing and imprinting the recently developed tactical skills. This period was subdivided by only two World Cup competitions, one in Warsaw and one in Padova. Preparation for the world championship or Olympic Games was completed by 2 or 3 weeks spent in a training camp.
During the studied 10 years the dates of the World Cup contests of selection changed very little (sometimes the locale of the event did change) so these were well comparable. Their time table, with respective numbers of preparatory weeks counted from the middle of September was:

1. Nancy 10-12 wks (venue replaced by Vienna between 1982 and 1985, and by Athens in 1992);
2. Moscow 16-18 wks;
3. Budapest 18-21 wks;
4. Hannover 22-24 wks;
5. New York 24-26 wks (venue replaced by Washington between 1990 and 1992);
6. Warsaw 28-31 wks;
7. Padova 32-34 wks.

The Padova Cup contests were followed by the two-day competitions of the French championship and –after a break of one week– by the training camp preceding the season's main event, the world championship or Olympic games. This means that preparation for the first World Cup of Nancy took on the average 11 weeks (mostly of basic conditioning). Then the respective World Cups followed every third week. The (French) national competitions and international team competitions occurred in the intervening weeks. Of the latter competitions the one called "Seven Nations" was the most important, yet I never regarded these as means for selecting prospective members of the national team. They as well as the weekly two training contests of the preparative regimen ("home competitions") merely served athletic preparation and acquisition of combat routine.

2. Subject material

The present study comprises the competitive and training measures of altogether 29 elite French sabre fencers. During the studied period of ten years 8 of the 29 competitors became members of the national team. Their training work and performance was recorded and analyzed individually as well as in a group. Thus there were three spheres of elite sabreurs:

a) a broader selection frame of 29. In the analysis 21 of them are designated as "not members of the national team";
b) a narrower selection frame of 8 competitors, subsets of which were
c) the 5 members of the Olympic or world championship team, respectively the 3 sabreurs for the individual events of the Games. Note that in the analysis the 8 of the "b" frame were treated as "members of the national team".

Of the team members three were adult competitors in 1982: Jean-Francois Lamour (born in 1956), Hervé Granger-Veyron (1958), and Philippe Delrieu (1959). They all had a competitive and training history of more than 10 years, but they had no international rank. The remaining 5 competitors' training history was of the same duration, but their combat experience was incomparably less. In 1982 they were still "juniors", and though

of an age of 19 or 20, they had got few if any individual lessons (a surprising fact considering that lessons are the most important part of a fencer's athletic preparation). They were: Franck Leclerc (1962), Franck Ducheix (1962), Pierre Guichot (1963), Jean-Philippe Daurelle (1963). The eighth one, Laurent Couderc (1969), became a member of the team several years later, at the age of 20.
Lamour and Guichot were members of the team along the whole period of 10 years. Delrieu belonged to the team eight times, Ducheix seven times, Granger-Veyron six times. It was 1989 when Daurelle became a team member for the first time; he and Leclerc were team members three times until 1992. The last one to get in was Couderc, after his junior years he was a member of the team of 5 twice: in 1990 and in 1991. The training stress and competitive activity of the remaining 21 elite sabre fencers was recorded and analyzed in a manner similar to those of the team members, though the 21 are not referred to by name here.

3. The weekly schedule of training work

The 14 weeks of basic conditioning were quite similar for all the 29 fencers. The amount of training work and competitive practice of the team members only became markedly different in the second and third period of preparation. The sessions of the training week were as follows.

Monday	1 session
Tuesday	2 sessions plus the swimming pool exercise
Wednesday	2 sessions
Thursday	1 session
Friday	2 sessions
Saturday and Sunday	contests.

Each session lasted two or two and a half hours. The afternoon of Tuesday and Friday was the time for our training contests. On Tuesday the swimming pool exercise followed the training contest. This sort of exercise represented a repetition of such tactical skills that developed against potential adversaries, learned in the individual lessons, and practised in the swimming pool and during the training contests until they were ripe to be used first at the national competitions, then at the World Cup competitions.
In addition to the two weekly practice contests the sessions of the other days consisted of conventional exercises, systematic bouts and free fencing, and taking lessons. In what are termed systematic bouts the two swordsmen alternately carried out previously assigned technical or tactical tasks. In free fencing no restrictions had to be observed. In 1982 and 1983 when we had to leave Friday afternoon, the morning session took place as usual. When we had to leave on Saturday or when the program was a French contest on Sunday, the afternoon session on Friday was normally completed by the training contest.

4. The objectives of the study, hypotheses of the research

By reviewing the work the French sabre fencers had done in 10 years I wanted to answer the following questions:

- ? Was there a difference in the competitive preparation and training work between the members of the national team and the elite swordsmen that had the opportunity to become members but failed to reach this goal?

- ? Which of the quantitative factors had the strongest impact on the performance at the main contests of the year (world championships and Olympic games): individual lessons with the coach; the number of contest bouts, the number of touches awarded in a bout; the number of victories scored, or the percentage of victories?
- ? To what extent and how well could performance at the respective World Cup competitions predict success (placing) at the world championships or Olympic games?
- ? Were all World Cup competitions of the same potential use in respect to the main contests of the year?

The a priori null hypotheses were:

H_0-1: more similarities than dissimilarities.
H_0-2: all factors positive and of the same weight.
H_0-3: importance growing with progress of season.
H_0-4: potential usefulness growing with progress of season.

5. Measurement of the recorded quantitative variables

As outlined above, in all the years between 1982 and 1992 there were 8 training sessions per week for 42 weeks. The log (training diary) contained five items in addition to the description of the event (number of the week, number of the three periods of 14 weeks each, training session/day or name and venue of the contest):

- ? Number of lessons taken (L)
- ? Number of bouts fought (B)
- ? Number of touches awarded (T)
- ? Number of victories (V)
- ? Success rate expressed as the percentage ratio of victories over bouts (S).

All the variables except S were regarded as measures of the training stress. S was regarded as the measure of performance. In the form of a protocol the log recorded these items for all the swordsmen so the great majority of the data can be retraced.

Table 1: Names and labels of the studied variables.

Number of time slice Competitions	1 Nancy	2 Moscow	3 Budapest	4 Hannover	5 New York	6 Warsaw	7 Padova	8 WCH/O	1–7 total	1–8 total
# of lessons	L1	L2	L3	L4	L5	L6	L7	L8	L_{1-7}	L
# of bouts	B1	B2	B3	B4	B5	B6	B7	B8	B_{1-7}	B
# of touches awarded	T1	T2	T3	T4	T5	T6	T7	T8	T_{1-7}	T
# of victories	V1	V2	V3	V4	V5	V6	V7	V8	V_{1-7}	V
Success rate	S1	S2	S3	S4	S5	S6	S7	S8	S_{1-7}	S
Placing score	P1	P2	P3	P4	P5	P6	P7	P8		

Abbreviation: WCH/O = world championships or Olympic games.

The numbered columns of the time slice were assigned to the seven World Cups. Column 8 refers to the year's main contest (world championship or Olympic games). The last two columns are summary measures (e.g., B_{1-7} = B1 + B2 + ... + B6 + B7, respectively B = B1 + B2 + ... + B7 + B8 = B_{1-7} + B8, but note that $S_{1-7}=(S1 \cdot B1 + ... + S7 \cdot B7)/B_{1-7}$).

Of the quantifiable measures of training stress the lessons were best suited to the development of qualitative features. Along with technical training, lessons involved the rehearsal of patterns and tactical skills carefully adjusted to the fencer's personality, his style of fencing, and his physical physical and mental characteristics. The tactical routines practised in the lessons as well as in the swimming pool were often of crucial importance in scoring a touch that essentially settled the outcome of a bout.

6. Statistical analyses

6.1. General considerations

The Statistica for Windows v. 6.0 software (Statsoft 2001) was used for all analyses.

For all the observed sabreurs the potential database would make 29 athletes by 10 years = 290 sets of observations, for the team members the same would be 80 sets. Because of missing data the actual number of data sets were 134 and 62, respectively. The level of random error to reject a null hypothesis was set at 5%. All the measures of the training stress could be regarded as being of the interval type (Garson 2001). Members of the national team were compared to non-members. Since for some measures the homogeneity of variances assumption could not be met, group comparisons made use of the Welch test for independent samples (Statsoft 2001) rather than the traditional t-test.

6.2. Considerations for data handling in multiple linear regression

The present analysis only deals with the quantitative factors of competitive and training work. It does not allow for qualitative aspects which otherwise can never be neglected. Most of these become unavoidably confounded under quantitative treatment despite that they are critical contributors to real-life bouts, touches, victories and lessons with an importance much beyond numerical relationships. However, we are still far from such theoretical constructs that could give account of them in the form of causal models of the respective sport events. For the time being we have to satisfy ourselves by scrutinizing what already can be analyzed. In doing so, however, one should do one's best to extract the greatest possible amount of information from the available data.
This was the reason why I thought it unsatisfactory to approach the points under study merely by presenting group differences and bivariate correlations. Quantitative aspects can be dealt with by regression techniques where the intention is to reveal the individual contribution of certain factors to the behavior of the variable to be explained (in the present case on the percentage rate of success at the main contests of the season). In disciplines governed by natural law (e.g., in physics) one strives to develop a mathematical formula or equation which estimates the unique share of the predictor variables in the change of the dependent for the individual case with a calculable

certainty and acceptable precision. In the social sciences the same precision is usually only approached.

Now an important objective of the analysis was the identification of variables that could explain, or had the strongest impact on, the performance at the last contest, respectively the victories scored during the last period of competitions. To come near this end several types of multiple linear regression were used. The raw R-square reflects the fit of the regression model to the data while the parsimony of the model is shown by the determination coefficient called adjusted R-square. The ratio of the beta weights shows the relative strength of the predictor's effect while the *b* coefficients show the change in the dependent due to a unit change in the predictor. A part of the regression analyses was performed by using the stepwise procedure; the criterion F-to-enter was 5% in most cases.

Regression estimates of the performance referred to two variables to be explained. These were: P8, i.e., the placing at the world championships or Olympic games (a measure restricted to the members of the team), and S8 which was a generalized index of performance during the last phase of the season and could be interpreted for both the team members and non-team members.

Collinearity problems could be resolved in part by using residuals and in part by applying the iterative selection of variables outlined below. These techniques are termed "indirect approach regression" in the section on results. In the tabulated results the tolerance associated with the predictors is $(1 - R_i^2)$, where R_i is the multiple correlation coefficient of the given independent variable for all the other predictors in the model. The conventional lower bound of tolerance in the social sciences is 0.20 at which multicollinearity needs no intervention yet (Garson 2001).

Where the model was affected by multicollinearity (predictor variables too closely related to one another), variables had to be separated into uncorrelated groups. Multiple regression alone – though it provides partial regression coefficients – does not suffice, because multicollinearity makes these coefficients unstable and their standard error gets inflated. Accordingly, the present study employed three complex methods of model development that could help in finding several blocks of variables affecting performance and were largely free of bias.

The essence of the first technique was that I removed those predictors from the model the regression coefficient of which was found significant in the stepwise procedure, then a new stepwise procedure was applied to the remaining variables. This was repeated until any of the variables had a significant coefficient. Starting from the indicator blocks obtained in the respective stages of iteration I strove to improve the fit of the model in two ways: either by adding variables from another block to the model, or – when entering a new variable caused another become insignificant – by replacing it by one belonging to another block. This approach involves subjective choices in developing the models so the eventual specification of the model does not necessarily conform to a theory. Nevertheless, when compared to a simple stepwise regression, a markedly larger part of the variance of the dependent variable can be explained in the long run. Since confounding is reduced, the technique has the additional bonuses of providing better measures of the predictors' relative importance, and of developing models in which all the predictors are significant. The only drawback is the great number of estimation runs.

The second technique to reduce multicollinearity was to replace collinear independents by the residuals from which variance common with the confounding other variable was removed. For instance, the independents B and T had consistently low tolerance when both were introduced in a model. That part of the variance which no longer had a common part could be identified as the residual variance of the equation: $T = a + b \cdot B$. The same was termed T_n_res and entered as a new indicator uncorrelated with either T or B to predict performance.
The third technique was the estimation of the logit transform of the variable S8. One of the issues of using logit transformation was considerable reduction of the collinearity problem. Another was the avoidance of a potential bias: Since the dependent variable S8 should vary between zero and 1, it would be a nuisance if predictor values farther from the mean resulted in estimates smaller than zero or larger than 1. Transformation of the variable to be explained should achieve conformity of that variable's range to those of its predictors. The logistic transform of logit_S8 = LN(S8/(1 – S8)) fulfils this requirement, where LN is the natural logarithm. The value range of the variable logit_S8 is the set of real numbers so the transform can assume small and large values at will. The disadvantage of the transformation is that the interpretation of the regression coefficient is no longer as direct as in the linear case where it numerically expresses the change in the dependent when the independent changes one unit.
In longitudinal studies like this one autocorrelation means a too systematic repetition of situations that may violate the assumption of independent observations. Bias due to potential autocorrelation along the ten years of study could be eliminated by taking the first-order temporal difference of the variables. This means that one had to subtract the value of year_{n-1} from that of the nth year. A comparison of the results referring to the differences and original data indicates whether there was any bias due to autocorrelation, and if so, how large.

7. Results and Discussion

7.1. Sample homogeneity

The first question to be answered was whether team members and non-team members constituted a homogeneous sample. Descriptive statistics for the studied variables show that only variable B1 failed to give a significant difference in favour of the team members. The null hypothesis that all the studied sabreurs belonged to the same population had to be rejected so further analyses had to be done separately for the two groups.
The same fact gave rise to further points worth considering:

? None of the 21 non-team members displayed a level of performance which would have justified their inclusion in the team frame (the burden of selection is never light for a national coach). That is, the group of 8 did perform at a higher level not merely qualitatively, but also by the quantitative measures of work.
? The analysis provided numerical evidence for the fact that the stress of preparation was the same for the 29 fencers in the 14 weeks of basic conditioning only. This was also supported by the non-significant difference in B1. In the World Cup competitions, which were used for selection, there were only 3 to 4 potential candidates for team

membership whose previous performance promised success.

? The 6 to 8 national contests of France and the weekly two practice competitions of the training regimen gave ample opportunity for the non-team members to acquire combat experience and to improve their indicators. Note the rather consistent and relatively small difference in the number of bouts when compared to other indicators.

? With progress of the season the difference between team and non-team members showed a gradual rise in the number of lessons while the same difference in the number of touches awarded as well as in the success rate was fairly large and nearly constant. Naturally the largest differences referred to end of the season when only one or another of the non-member group could participate in the final phase of preparation.

Table 2: Summary results of estimating S8 by regression models containing 28 variables (T1...T7, B1...B7, L1...L7, S1...S7).

Team membership	Yes	No
R	0.878	0.903
R^2	0.772	0.815
adj. R^2	0.572	0.168
F-reg(df1;df2)	3.86	1.26
(df1;df2)	(28, 32)	(28, 8)
F-reg P<	0.000	0.388
SEregr.	0.069	0.108

Abbreviations: R = multiple correlation coefficient;
R^2 and adj. R^2 = raw and adjusted multiple determination coefficient (R-square);
F(df1;df2) = omnibus F-test of the regression model; (df1;df2) = degrees of freedom for the F-test;
P< = significance level of the F-test; SEregr. = standard error of the regression.

7.2. Regression analysis of the first (direct approach) model

Regression results of the model in which S8 (the performance indicator of the last phase of the season) was the dependent, and the lessons, bouts, touches awarded and success rates of all the previous time slices (L1 through L7, B1 through B7, T1 through T7, and S1 through S7) were the predictors, are summarized in Table 2 for both groups, and detailed separately for the team members and non-team members. These showed that satisfactory precision could not be attained for estimating individual scores realistically. Compared to the raw coefficient of determination a particularly sharp fall was noted in the adjusted value of R-square for the non-team members the reasons for which were the large number of predictors and few degrees of freedom. The R-square of model fit demonstrated that for the team members 77.2% (and for the non-team members 81.5%) of the variance in S8 was accounted for by these explanatory variables. Expressed in the units of the dependent the standard errors were 6.94 and 10.8%, respectively. For predictive purposes these were the bounds of uncertainty for this model: unfortunately too broad to be valid for observation units smaller than a group.
This model also threw light on other problems that the researcher interested in the relationship between training work and sport performance should be aware of. As shown by the results, a good deal of the predictors had very low tolerance. This arose from the very close correlation of some of the independent variables. As outlined in section 7.2, this statistically untoward situation termed multicollinearity required special measures, in particular since it affected the models of both groups.

7.3. Regression analysis of the indirect approach models for the team members

When S8 was chosen as the dependent variable to be explained, three possible models were found by the iterative procedure (Table 3). The first one (top block) could be interpreted relatively easily: each of the four indicator variables exerted a positive effect on S8 and explained 68.9% of S8 variance. It is noted here that trials to replace S1, S2, S4, and B5 by the S or B variables of another time slice gave consistently much poorer fit. The coefficients of the second and third models gave a more complex pattern while their explanatory power necessarily decreased (the R-squares of 57.4% and 54.4% lag by more than 10% behind the first model). The B and T variables of the corresponding time slices had an opposite effect on S8. This would not be surprising within a time slice since the performance of a fencer who scores more touches in a given number of bouts is better. However, the same was observed across different time slices as well: fencers fighting more bouts in previous World Cups had a poorer performance in the last phase. A pairwise comparison of the standardized regression coefficients (beta weights) made it obvious that the opposing effects were of the same relative magnitude. The significant success rates of all the previous sections were positively related to that of the last phase. The success rate S5 is missing from the models because its effect was very slight.

Table 3: Models of multiple regression estimating S8 for the team members.

Var	b	SEb	beta	SEbeta	t(56)	P<	Toler.	Regression	Value
Constant	0.027	0.055			0.50	0.622		R	0.830
S2	0.365	0.098	0.363	0.098	3.71	4.8E-4	0.581	R^2	0.689
S1	0.237	0.107	0.249	0.112	2.22	0.031	0.441	adj. R^2	0.666
S4	0.217	0.055	0.247	0.115	2.14	0.036	0.418	F-reg(4;56)	30.95
B5	0.001	4.9E-4	0.177	0.084	2.12	0.038	0.796	F-reg P<	1.3E-13
								SEregr.	0.061

Var	b	SEb	beta	SEbeta	t(54)	P<	Toler.	Regression	Value
Constant	0.426	0.081			5.26	0.001		R	0.758
B2	–0.003	0.001	–1.267	0.584	–2.17	0.035	0.023	R^2	0.574
T2	0.001	2.9E-4	1.171	0.576	2.03	0.047	0.024	adj. R^2	0.527
B1	–0.004	0.001	–1.147	0.392	–2.93	0.005	0.051	F-reg(6;54)	12.15
T2	0.001	2.9E-4	1.171	0.576	2.03	0.047	0.024	F-reg P<	1.4E-8
T1	0.001	2.4E-4	0.943	0.386	2.44	0.018	0.053	SEregr.	0.073
S6	0.347	0.088	0.381	0.097	3.92	2.5E-4	0.833		
T5	2.9E-4	1.2E-4	0.252	0.100	2.52	0.015	0.786		

Var	b	SEb	beta	SEbeta	t(62)	P<	Toler.	Regression	Value
Constant	0.184	0.064			2.87	0.006		R	0.738
T4	0.001	2.7E-4	0.661	0.313	2.11	0.039	0.082	R^2	0.544
B4	–0.002	0.001	–0.596	0.307	–1.94	0.057	0.087	adj. R^2	0.515
S7	0.393	0.090	0.440	0.100	4.39	4.4E-5	0.750	F-reg(4;62)	18.49
S3	0.257	0.092	0.285	0.102	2.79	0.007	0.705	F-reg P<	4.8E-10
								SEregr.	0.074

Symbols: b = value of the intercept (constant) and regression coefficients; beta = standardized regression coefficients; SEb and SEbeta = standard errors of the unstandardized and standardized regression coefficients; t (df) = t-test of coefficient significance; P< = significance level of the regression coefficients; Toler. = tolerance; R = multiple correlation coefficient; R^2 and adj.R^2 = raw and adjusted multiple determination coefficient;

F-reg(df1;df2) = F-test of the model; F-reg P< = significance level of the model F-test; SEregr. = standard error of regression. Variables are ordered by beta weight. Variable labels in column 1 as in Table 3.

For the coach planning training work the effect size of the success rates in the early part of the season (S1, S2 and S4) may be of particular interest: model 1 had to do with the World Cups of Nancy, Moscow and Hannover (end of December, respectively the 2 to 3 weeks of preparation in January and February), and could explain more than two-thirds of the variance of the success rate at the Games or world championships. This observation deserves more thought even when one must be aware of the fact that regression analyses cannot be used to evidence causal relationships.
Again, for the coach analyzing ways to attain top performance models 2 and 3 also have a message. When we regard the 29 French sabreurs as a sample rather than as a population, the observation that B1, B2 and B4 were all negatively related to S8 may be interpreted as follows. If feasible, it is preferable to attend only those competitions of importance at which there is high probability of winning. Too many full risk competitions are likely to exert a saturating effect and adversely influence performance at the main events of the season.
Anticipating the interpretation of the models coming later I am ready to admit that several of the regression results were unexpected and surprised me. One of these was that S5, i.e. the success rate in the World Cup period of New York, failed to reach significance for S8 in any of the studied models. I believe that preparation for this contest was important, but our participation at it had more to do with sports diplomacy (jury work) and psychic factors. Without an accurate recording and a thorough analysis of data it is much more difficult to discover which occasions of competitive preparation are really important and which are less so for end-of-season performance.
Regressions estimating the logistic transformation of S8 (logit_S8) provided very little additional information. Their main value was as a confirmation of the already observed relationships of S8: the success rates of the previous World Cup periods could explain about 59% (for Nancy in December, Budapest in February and Padova in May) to 68% (for Moscow in January and Hannover in late February) of logit_S8 variance as evidenced by the R-squares. The absence of the predictive power of the New York Cup competitions was also noted here.

7.4. Regression analysis of the indirect approach models for the non-team members

Here too the number of the obtained models for predicting S8 was three, but their quality of fit was rather poor, none of them could account for even 50% of variance. Fewer of the indicator variables of the respective contest periods were found to relate significantly to S8 so I decided to include summary variables as well (L_{1-7}, B_{1-7}, T_{1-7}). As for the team members, this resulted in the multicollinearity problem with low tolerances and in a similar opposing effect of T and B. The negative effect of the lessons did not depend on collinearity, all three models showed this phenomenon.

To parallel the estimates for the team members regression models using the logistic transform of S8 were run also for the non-team members. Here again the proportion of explained variance was less than 50% in all three models found. The best fitting model contained the transforms of an early and a late phase success rate measure. The collinearity problem arising from the concomitant inclusion of corresponding T and B variables impaired two of the models. The inference was that logistic models had a comparable or minimally better fit, a more round-about interpretation and failed to avoid low tolerances. The analysis shows the only first-order difference model for the non-team members that was still acceptable with respect to model fit. While for the team members the touch residuals of the earliest and latest contest periods (T1_res and T7_res) appeared in separate models, for the non-team members they were found to be significant concomitantly. This model resembled that of the team members in another respect as well, namely that predictors of the same type (T_n_res and L) but referring to different time slices had an unexpected opposite effect on the yearly difference between the final success rates.

7.5. Summary conclusions

Preparation of the best French sabre fencers for the world championships and Olympic Games was found unsatisfactory with respect to both competitive practice and training work, and therefore needed fundamental reshaping. To gauge the effect of the changes introduced the number of the lessons, bouts, touches, and intraseason victories were carefully observed and recorded through ten years. This paper deals with some particular aspects in the analysis of these data.

The marked differences in almost all the studied quantitative measures of competitive preparation and training work disallowed a common treatment of these elite sabreurs, the 8 who performed well enough to become members of the national team had to be discriminated from the second ranks of swordsmen.

In order to extract the greatest possible amount of information latent in the data iterative techniques of regression were applied in addition to the conventional direct approach. In search of the best predictor for the end-of-season success rate, specific techniques were required to handle the problems associated with the complex relationships between the observed data. Multicollinearity was strongest between bouts and touches, but even the number of lessons happened to relate too closely to the success rates of certain periods. The really efficient technique to deal with the multicollinearity problem was the use of residuals of which the collinear contaminant variance was partialled out. The question of whether autocorrelation did or did not bias the estimated regression could not be settled to satisfaction: first-order differences were associated with information loss, and the results were largely similar but not directly comparable to those with the original data.

By applying iterative regression techniques several models were developed to account for various aspects of the complex relationship between the studied quantitative measures of preparatory work and the success rate at the main contests of the season. These models drew attention to unexpected, sometime surprising effects: reciprocal influences, effects developing after considerable time lag (e.g. suggesting that certain lesson effects may become manifest in the next season only), and – last but not least – the variable importance of the respective World Cup competitions for the eventual success rate.

The best fitting models for the team members were:

$S8 = 0.027 + 0.237 \cdot S1 + 0.365 \cdot S2 + 0.217 \cdot S4 + 0.001 \cdot B5$ ±0.061; adj.R^2 = 0.666;
$S8 = 0.541 - 0.002 \cdot L_{1\text{-}7} + 0.0039 \cdot B_{1-7} + 0.0005 \cdot T_{1-7}\_res + 0.906 \cdot S_{1-7}$ ±0.065; adj.R^2 = 0.630;
$S8 = 0.184 - 0.002 \cdot B4 + 0.001 \cdot T4 + 0.257 \cdot S3 + 0.393 \cdot S7$ ±0.074, adj.R^2 = 0.515.

For the non-team members they were:
$S8 = 0.188 + 0.488 \cdot S1 + 0.325 \cdot S7 - 0.014 \cdot L6$ ±0.084; adj.R^2 = 0.432;
$S8 = 0.152 + 0.53\,4 \cdot S1 + 0.352 \cdot S7 - 0.001 \cdot\cdot L_{1-7}$ ±0.087; adj.R^2 = 0.384;
$S8 = 0.546 - 0.002 \cdot L_{1-7} + 0.0037 \cdot B_{1-7} + 0.00041 \cdot T_{1-7}\_res + 0.857 \cdot S_{1-7}$ ±0.097;adj.R^2 = 0.324,
where
B: number of bouts,
L: number of lessons taken during both the training sessions and competitions,
S: success rate = the number of victories divided by the number of bouts,
T: number of touches given,
res: residual of which the effect of the collinear variables had been partialled out,
while the numbers following the variables denote the periods of the season of which the eighth referred to the period of the world championships and Olympic Games.
The standard error and adjusted R-square of the model is shown on the right of the equations.

The quantitative analysis of the competitive and training stress contributed a lot to the understanding of the improving international performance of the French sabreurs in the studied period and, to some extent, in the times following it. Jean-François Lamour became Olympic champion twice: in Los Angeles in 1984 and in Seoul in 1988, and became individual champion of the Lausanne world championship in 1987. The team of the Raçing Club (Lamour, Guichot, Delrieu, Ducheix and Bolle) won the European Cup of the Champion Teams in 1990. Every member of the French national team (Lamour, Guichot, Delrieu, Ducheix, Daurelle and Granger-Veyron) was either a medalist or a participant of the individual finals at the recent world championships or Olympic Games. These are unique and unparalleled events in the one hundred year history of French sabre fencing.

Acknowledgements

The author is greatly indebted to Mr. L. Berény for his help in the statistical analysis and to Mr. I. Szmodis for his valuable comments.