A KEY PERFORMANCE INDEX TO RANK THE SAFETY AND LIFESPAN OF SABRE BLADES

Vincenzo Castrucci and Andrea Mazzarano[1], SS Lazio Scherma Ariccia, Italy

*This follows on from a previously published article 'Preliminary Investigations On Sabre Blade Ruptures During Fencing' (*The Sword*, to be published 2018).*

In recent years a general trend has been observed in the shortening of the lifespan of sabre blades, particularly for fencers U14 and U17. Unfortunately, due to the lack of any systematic approach in evaluating this problem, these observations have so far remained purely anecdotal. However, in 2015, a fencing team in Italy (SS Lazio Scherma Ariccia), hit in 2014 by a severe injury on one of its fencer due to an anomalous (jagged) break of a sabre blade in a national competition, decided to start a project to monitor the lifespan and occurrence of anomalous breaks of the sabre blades used by its fencers.

The aim of this project was to study:

- The phenomenon of the ***anomalous breaks*** of the blades
- The ***lifespan*** of the blades
- Possible links between ***anomalous breaks***, lifespan of the blades and the characteristics of the fencers (gender, weight, age etc.)
- And to try to verify the link between the ***lifespan*** of blades and ***characteristics*** of the fencers.

The results were presented last June (2016) during an Italian Senior fencing championship (1).

In **Figure 1** the percentage of anomalous breaks is measured on a set of 96 sabre blades of 10 different kinds.

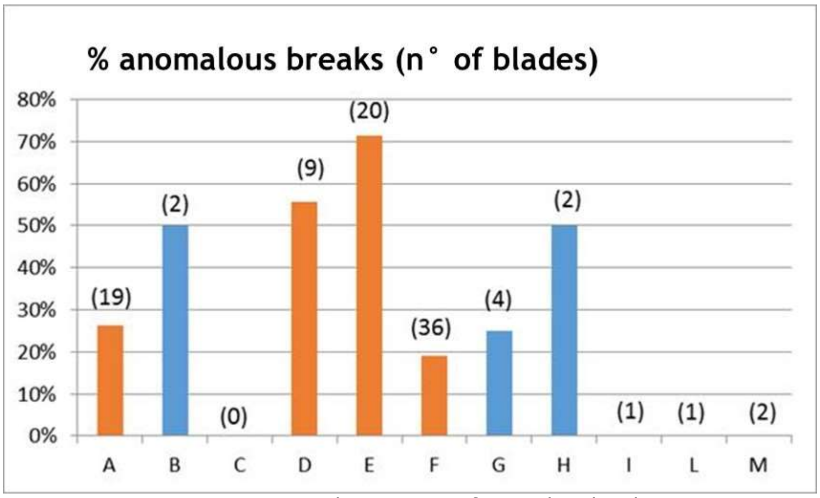

Figure 1 Measured percentage of anomalous breaks

The main conclusions were:

- It is possible to differentiate the typical lifespan of blades, by gender and by varying characteristics of fencing

[1] andrea.mazzarano@gmail.com

- Technical fencers are generally gentler with their blades, in comparison to more physical fencers
- The amplitude of the monitored sample has an impact on the absolute values of the anomalous breaks, but not on the trends
- No evidence of a correlation between anomalous breaks and lifespan has been observed.

Sabre blades are often subjected to wide ranging levels of stress; sometimes demonstrated in very spectacular photographs (see **Figure 2**). Sometimes the applied stresses are elastic and sometimes they result in plastic deformations of the blades.

Figure 2 (photo by Augusto Bizzi) snake type of blade bending

Gender, weight and speed of fencer can make a blade behave differently. This means for example that the same blade might perform very well in the hands of a technical female, but very badly in the hands of a physical male; in both terms of safety and lifespan characteristics.

Having regard to these things and the sheer lack of information currently available from blade suppliers and the FIE on the likelihood of injuries to fencers, SS Lazio Scherma Ariccia decided to advise its fencers against the use of the blades which demonstrated a significant tendency to anomalous breaks, in particular blades D and E. This decision was applied independently of gender, even though the blade E displayed a very significant difference in the rate of anomalous breaks observed for males and females (1). At the same time it was decided to continue this project by monitoring other kinds of blades.

Even though no direct correlation was found between the tendency of anomalous breakages and the lifespan of blades, nevertheless, their values were considered to be important when deciding which blades to select on the grounds of safety and cost.

If we take the example of an U17 fencer, training 40 weeks per year, 5 time a week, 5 bouts per training session (including try-outs with the coach, which we take to be comparable to a bout), we get a total of 1000 bouts. 1000 bouts per fencing year can then be taken as a comparison (excluding competitions, where the fencer may use a specific sabre).

Now, without taking into considerations the feeling of the individual fencer, with his/her sabre (shape, weight, flexibility etc.); but imagining that each fencer would use only one kind of blade; the different available blades may be ranked in terms of how many blades the fencer needs for executing 1.000 bouts (the “l” parameter) and with the lowest number of anomalous breaks (the “a” parameter). The higher the lifespan, the lower the maximum expected number of anomalous breaks.

So, we decided to study whether or not it is possible to determine a key performance index (KPI) which is able to incorporate anomalous break occurrence (parameter “a”) and lifespan (parameter “l”).

From what understood in (1), and in particular that the gender has shown a significant impact on lifespan of blades, two subsets of data available from (1) and (3) have been taken here into consideration: one for male fencers and one for female fencers.

Thanks to the number of available experimental values of lifespan and anomalous break experienced (ref. 1 and 3), for female fencers two kinds of blade are taken into consideration, while for male fencers only one is deemed available. In **Table 1** the values of “l” and “a” are shown.

Case	Gender	N°	Blade	(a)	(l)	b	c	l/a
1	Male	4	A	0,25	63,50	16	4	254
2	Male	5	D	0,40	16,60	60	24	42
3	Male	5	E	0,80	62,00	16	13	78
4	Male	38	F	0,13	29,89	33	4	227
5	Female	7	D	0,86	28,29	35	30	33
6	Female	6	E	0,33	65,33	15	5	196
7	Female	12	F	0,17	33,17	30	5	199

Table 1: subsets of values of blade behaviour from (1) and (3)

In the **Table 1**, the different parameters stand for:

N° = number of tested blades
Blade = kind of blade tested
(a) = rate of anomalous break
(l) = lifespan of blades
b = number of a kind of blade needed for executing 1.000 bouts
c = number of a kind of blade with anomalous break forecast in 1.000 bouts.

In the case 1, a male fencer for concluding 1.000 bouts should use 16 blades of kind A (“b” value for blade A), of which 4 blades (i.e. the 25% of the 16 blades used) would show an anomalous break.

The simplest performance index is proposed as the ratio between parameters “l” and “a”, and the relevant values are presented on the last column on the right of **Table 1**. While for male fencers it seems clear that among the kind of blades tested the best behaviour is for the blade A which shows the highest l/a value equals to 254, followed by blade F with l/a = 227. The l/a values quite close shown by those two kinds of blades would suggest behaviour quite similar, and this is true for what concerns the forecast value of anomalous breaks over 1.000 bouts, which is equal to 4 for both blades. What the l/a performance parameter is not able to show is that this identical forecast values of anomalous breaks over 1.000 bouts is obtained by the two blades with very different amount of blades: 16 for blade A and 33 for blade F.

A similar exercise can be done with the values obtained by female fencers. If one female fencer should decide about blade E or F, which show the same “l/a” parameter (respectively 196 and 199), if one should follow only the safety parameter the choice would be F. If instead the lifespan, parameter "l" is also taken into consideration, then the choice would be blade E, because the total number of blades to be used for executing 1.000 bouts would be 15, 50% of those needed by using blade F.

The above exercises shows very clearly the significant impact of lifespan in determining the optimal option for safer fencing and the fact that the safest blades should be those showing the lowest value of "a" parameter coupled with very high values of "l" parameter. As the correct choice of safer blades were done in the above exercise by introducing the parameter of 1.000 bouts, it is here proposed to calculate a further parameter obtained multiplying the number of blades needed for 1.000 bouts per the number of blades forecast to present anomalous breaks. In **Table 2** the values are shown in the first column in the right, calculated by multiplying the integers from column "b" and "c".

Case	Gender	N°	Blade	(a)	(l)	b	c	l/a	b*c
1	Male	4	A	**0,25**	63,50	16	4	254	64
2	Male	5	D	**0,40**	16,60	60	24	42	1440
3	Male	5	E	**0,80**	62,00	16	13	78	208
4	Male	38	F	**0,13**	29,89	33	4	227	132
5	Female	7	D	**0,86**	28,29	35	30	33	1050
6	Female	6	E	**0,33**	65,33	15	5	196	75
7	Female	12	F	**0,17**	33,17	30	5	199	150

Table 2: values of different parameters obtained for different saber blades

Comparing the values obtained for cases 1 and 4, it can be easily seen that the new key performance index proposed correctly puts in evidence the real difference in behaviour of the blades: the "b*c" value calculated for A blade is just a half of that obtained for F blade, 64 against 132. Similar conclusion can be taken comparing case 6 and case 7.

Maintaining the differences between male and female fencers, it is possible now to rank the different blades in terms of safety and lifespan, as shown respectively in **Tables 3 and 4**.

Case	Gender	N°	Blade	(a)	(l)	b	c	l/a	b*c
1	Male	4	A	0,25	63,50	16	4	254	64
4	Male	38	F	0,13	29,89	33	4	227,2	132
3	Male	5	E	0,8	62,00	16	13	77,5	208
2	Male	5	D	0,4	16,60	60	24	41,5	1440

Table 3: ranking in safety of different tested saber blades for male fencers

Case	Gender	N°	Blade	(a)	(l)	b	c	l/a	b*c
6	Female	6	E	0,33	65,33	15	5	196	75
7	Female	12	F	0,17	33,17	30	5	199	150
5	Female	7	D	0,86	28,29	35	30	33	1050

Table 4: ranking in safety of different tested saber blades for female fencers

In these rankings, the D blade results the worst both for male and female fencers. The blade E instead, results quite bad when used by male fencers, while is the best if used by female fencers.

The results shown in **Table 3 and 4** are strictly depending on the characteristics of the fencers used as tester in SS Lazio Scherma Ariccia training hall. Maybe in a different training hall the same blades could offer different behaviour.

It means, and it is here strongly suggested, that a specific test is designed in order to characterise the blade in terms of "a" and "l" parameters. The test of course has to take into consideration the different characteristics in weight and speed of female and male fencers.

Further, the minimum number of sampled blades should be wide enough, and we suggest at least 10 blades of the same kind.

The testing machine should be such that the sabre blade can be bent against a target under specific applied parameters, first of all the speed of impact, or, better, something like a thrust, able to link together the speed and weight of the fencer.

In fact, it has been clearly demonstrated that shape of blades and speed of direct shot can have a very significant impact in determining the lifespan and the tendency to anomalous break (2).

In order to understand the levels of speed reached by fencers during bouts a new study has been commissioned (3).

References:

(1) V. Castrucci, A. Mazzarano, "SAFETY & LIFESPAN OF SABRE BLADES: Preliminary results", Rome (Italy), 11th June 2016, available at www.sslazioscherma.com.
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(3) V. Castrucci, A. Mazzarano private communication, December 2016.