IMPACT FORCES OF THE BLADE IN FENCING MOVEMENTS

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Fencing is a sport in which the contact between the opponents occurs through weapons: foil, sword and sabre. In order to avoid any physical harm, the athletes wear proper equipment, specially designed to protect against the impact of the blade. The protective performance of the equipment dramatically decreases when the blade accidentally breaks during the impact. This event, which occurs more frequently with the foil, may give rise to tragic consequences.

The knowledge of the force exchanged between blade and target is the fundamental step towards designing safer equipment and to choosing the most appropriate steel for the blades.

Despite its importance, few researchers have studied the problem. One example is given by Klinger and Adrian (1983). who measured the acceleration of the handle during the impact of the foil with different targets. The purpose of this investigation was to measure the force exerted by the tip of foil and sword blades during fläche and lunge actions, performed by athletes of different age. and skills.

METHODOLOGY

Fifteen fencers were the subjects of the study grouped as follows: five young foilists (beginners), five adult foilists and five épéists, the latter groups being of international level. The fencers were asked to hit an aluminium circular target (diameter 160 mm) covered with a sheet of EVA foam (height 10 mm) end mounted on a three component load cell. The cell-target system was fixed to a pillar of cement by means of a mechanical device, designed in order to adjust the height of the center of the target from the floor and to ensure the right alignment of blade, wrist and shoulder of each subject

Two basic movements were studied: fläche and lunge. All the subjects performed the experiments by using weapons with new blades. The foilists repeated the movements with foils fitted with three different handles: Italian, French and anatomic. The latter was used as the handle for all the swords.

The signals were acquired with a sampling frequency of 1000 Hz and filtered with a numerical low pass filtering, with a cut-off frequency of 300 Hz. This value was chosen when considering the free frequency of the measurement device as a whole.

The maximum of the peak of force (Mf) and its integral (If) for the first 50 milliseconds of the impact were computed for each trial.

RESULTS

The typical time course of the modulus of force is depicted in Figure 1. The recording is of the lunge of a foilist, who maintained the tip of the blade on the target after the hit.

On observing the curve's pattern it is possible to divide the phenomenon into three main phases. The first phase covers the

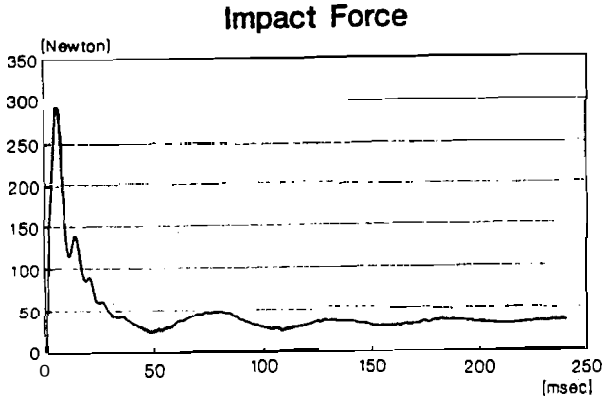

Figure 1. Time course of the impact force modulus measured during a foil lunge.

The first 50 msec and describes the peak of force, which has an amplitude strictly dependent on kinetics and mechanical stiffness of blade, fencer and target. From approximately 50 to 250 msec, the force is a smoothed sinusoid which has a fundamental harmonic mainly related to the vibrations of the blade, which is constrained at both ends. The third part is the constant load transmitted by the blade as a consequence of its stiffness and amount of deformation (distance between both ends).

Figure 2 shows the histograms describing the mean value and standard deviation of Mf and If measured during the experiments. Looking at the results obtained by the three groups of fencers (A, A'), it was evident that the sword transmits higher peaks of force than the foil; the same is true for the intergral. The mean value of the peak range from 284 to 375 N and from 301 to 358 N for fläche and lunge respectively. The integral ranged from 2.64 to 4.27 N/s, this means that there is the application of a between peaks and integrals were not supported by a statistical significance.

The results of the use of foils with different handles are reported in B and B'. The test performed by the group of young fencers points out values ranging from 282 to 398 N measured during fläche and from 303 to 358 N during lunge. At the same time the mean values of the integral were very similar (248-285 N/s). It was possible to observe that the foils with an Italian handle had, the highest mean peak of force but, once again,

a statistical significance does not support the differences among the handles.

The histograms on the bottom (C and C') depict the results obtained by using blades made with different steels. Steel A was the most common steel put into practice while B was a type of steel with particular mechanical characteristics (high fatigue limit and toughness).

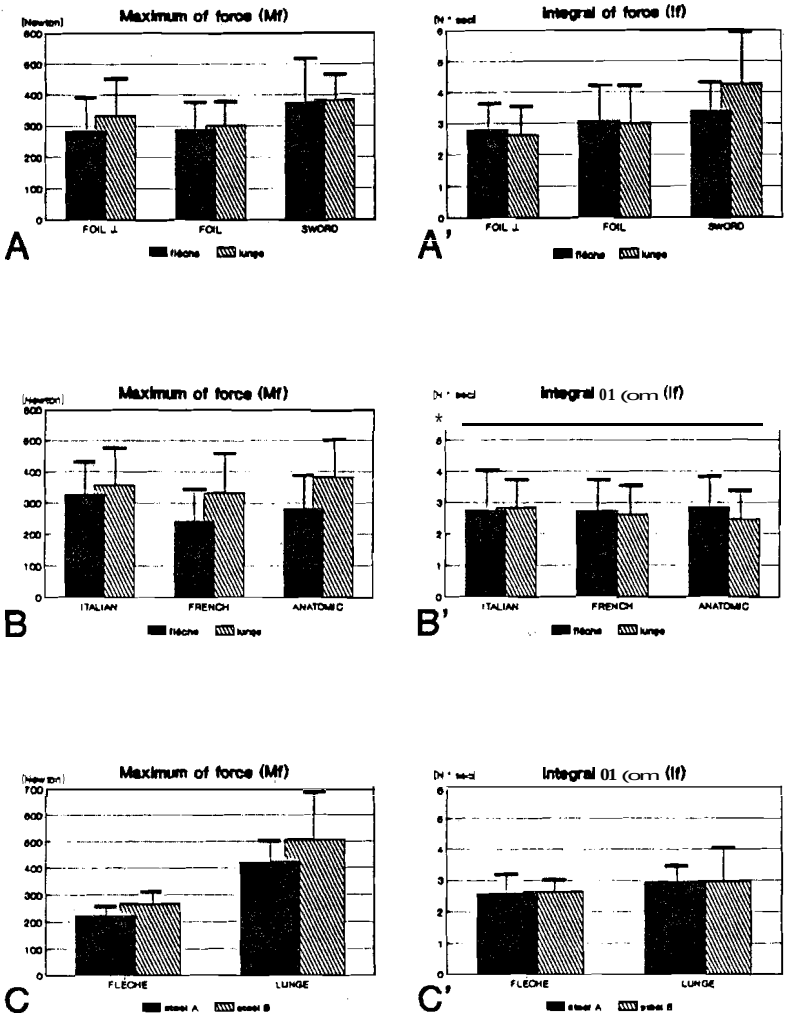

Figure 2. Histograms representing mean value and standard deviation of Mf and IF.

The peak of force transmitted by Steel B is significatively greater than that transmitted by Steel A, and this is confirmed in both movements. Moreover, the difference is more evident when the impact is characterized by the higher speeds typical of the lunge. The standard deviation associated with Blade B during the lunge is, approximately twice that of Blade A in the same conditions. Contrary to the peak, the values of the integral are very similar.

CONCLUSIONS

The results of the study enable us ℮ identify the following criteria, aimed at helping to design safer weapons and protective equipment.

1. The characteristics of the force transfer from the blade ℮ the target during fencing strokes are those of an impact, which timecourse depends on unpredictable factors typical of the agonistic circumstances and on the mechanical characteristics of the blade and its geometry. Therefore, it would ℮ advisable ℮ set up a specific mechanical test based on these findings ℮ better control the blade.
2. The épéists are exposed ℮ greater exchanges of forces than foilists, which may ℮ strongly influenced and modified by unforeseeable factors. Some attention must ℮ paid to the foilist: the two groups exert the same force inspite of the young fencers using shorter blades with a smaller cross section area and while moving the weapon more slowly.
3. The handle does not influence the impact, so the choice of a particular kind of handle is the personal and technical preference of the athlete.
4. The mechanical characteristics of the steel in the blade has a significant influence on the impact. The tendency to use steel with a higher fatigue limit and toughness, useful in avoiding accidental breakages, is acknowledged in terms of higher peaks of force. This problem is wholly secondary when compared ℮ the case of a breakage, and it may ℮ easily overcome by means of extra padded protective devices.

ACKNOWLEDGEMENT

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REFERENCE

Klinger, A.K. & Adrian, M.J. (1983) Foil target Impact forces during the fencing lunge. In *Biomechanics VIII B*, Ed. H. Matsui and K. Kobayashi, 882-888.