

WHAT THE BIOMECHANICS RESEARCHER TELLS THE DIVING COACH AND WHAT THE COACH TELLS THE RESEARCHER

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The concern for "bridging the gap" between theory and practice is not new to researchers in biomechanics. In many sport application areas, however, the gap is still unacceptably large. The responsibility for closing it (and it is indeed getting smaller in some cases) rests with all concerned: sport governing bodies which control funding and information dissemination to their constituents; coaches who need to be informed consumers and to provide the cooperation vital to support ongoing research; and biomechanics researchers who must actively seek to dialogue with practitioners, provide expertise in mechanical analysis applied to the particular sport and furnish timely feedback in a format meaningful to coaches and senior athletes.

In springboard diving, as in gymnastics and track and field, an understanding of applicable mechanical principles can greatly facilitate instruction, error detection and correction of performance. Because of this close link, biomechanics research in these sports has the potential for contributing significantly to the training of teachers and coaches and to the improvement of individual performances. To realize this potential, however, it is important to have open two-way communication between researchers and practitioners. To be most effective, the information flow between the two groups must deal with issues important to successful performance and must be in terms which are meaningful to both.

In an ongoing study undertaken through the cooperation of the Canadian Amateur Diving Association (CADA), we are attempting to achieve these objectives by: 1) providing general information on the mechanical basis of the springboard take-off which will be useful for the education of teachers and coaches; and 2) developing an appropriate feedback system (both in terms of content and format) to furnish coaches and athletes with specific biomechanical data on the execution of particular dives. It is upon the second phase of this project that this paper will focus.

PROCEDURES

In March of 1982 we filmed the preliminaries and finals of the women's 3 m springboard competition at the Canadian National Diving Championships held at the Vancouver Aquatic Centre. Because of the excellent cooperation of meet manager and national coach, Irene MacDonald, we were able to position the camera in the first row of the balcony approximately 25 m back from and directly in line with the ends of the boards being used in the competition. She also made it possible for us to mark a 1.8 m linear scale reference on the side of each board, obtain the diver's weights and get copies of the diving

order as well as the judges' score sheets. During the finals we had the benefit of CBC TV lights which permitted us to film easily at a frame rate of 100 per second.

Dives from the forward and reverse groups (i.e., those with a running approach) were filmed for 8 of the top 12 competitors. To provide a large image for digitizing, the field of view was limited to the final two approach steps, take-off and that portion of the flight which was approximately 2 m above the water. In both the digitizing and subsequent computer analysis, the diver was assumed to be moving symmetrically in the principal plane of motion. Notes were made when this assumption was violated. Although the primary focus of the analysis was on the take-off (that period between the hurdle and the flight), limited information concerning the approach and hurdle was also obtained.

RESULTS AND DISCUSSION

Although not as yet in final form, information returned to the CADA and participating coaches included the following.

Approach and Hurdle

Length of the final two approach steps and the hurdle, time in the air (if any) during the last approach step and during the hurdle, and extent of springboard depression preceding the hurdle were grouped by diver and served to reveal any major discrepancies from the "norm." One competitor, for example, had a hurdle about .25 m longer than the others. This meant her foot plant in the final approach step was positioned so far back from the tip of the board that her springboard depression on going into the hurdle was curtailed and her hurdle height reduced. The resulting reduction in the time in the air for the hurdle combined with the longer distance to be covered to reach the end of the board necessitated a high forward velocity, the influence of which carried right through the take-off and on into the flight. Thus the reason this diver entered the water further from the board than the others could be traced back to the position of her final approach step.

Take-off

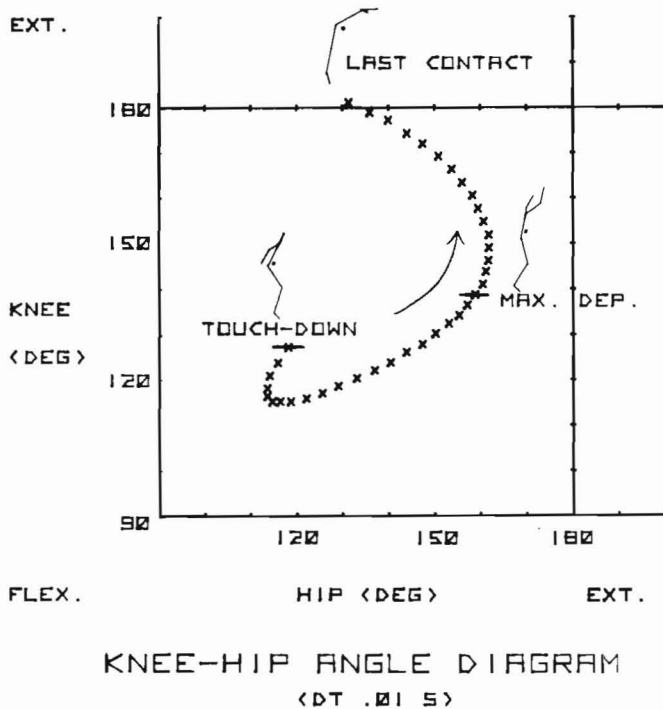
To facilitate analysis and discussion, take-off was subdivided into two phases each of which had physical significance for the performance and could be easily identified visually. These phases were depression of the springboard and its subsequent recoil.

Position. A series of stick figures plotted from the coordinates of segmental endpoints clearly showed the relative orientation of the body segments and the location of the center of gravity. These figures provide useful information on such variables as trunk lean and arm position throughout depression and recoil. Foreshortened arm segments indicate motion outside the plane of the somersault.

Knee-hip angle diagrams portrayed the angular displacements of the lower extremities and trunk during the take-off. The data provided in Figure 1

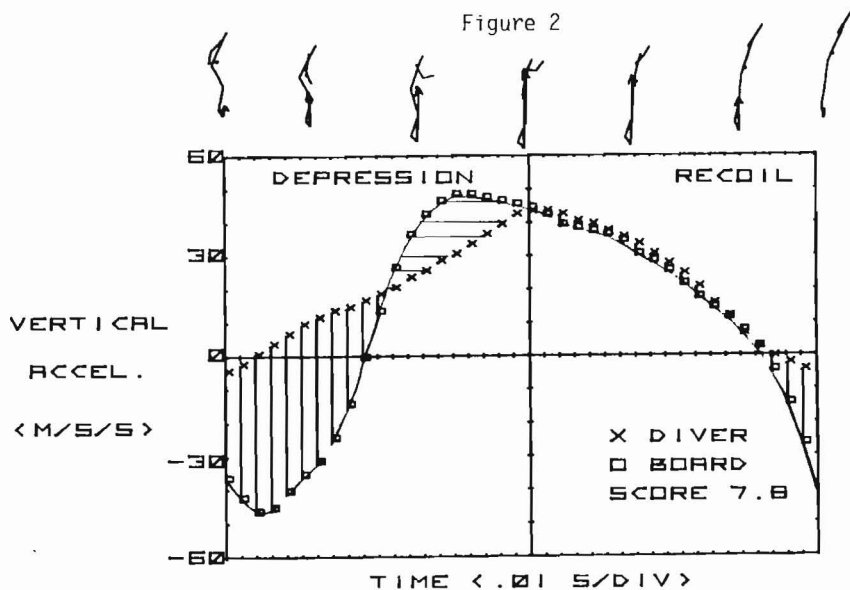
from a forward $2\frac{1}{2}$ somersault in the pike position show that hip and knee flexion continue for a short period immediately after touch-down. This is followed by extension of the hips and knees for the remainder of depression and into the beginning of recoil. Then as the knees continue to move toward complete extension, the trunk flexes to aid in the initiation of forward somersaulting angular momentum. When knee-hip angle data from various dives are superimposed on the same diagram, divergence of the curves clearly indicates where the rotational requirements of specific dives first have a noticeable effect. An excessively early separation in high degree of difficulty dives may suggest that the diver is "rushing the board" (i.e., anticipating the flight too soon in the take-off).

Figure 1



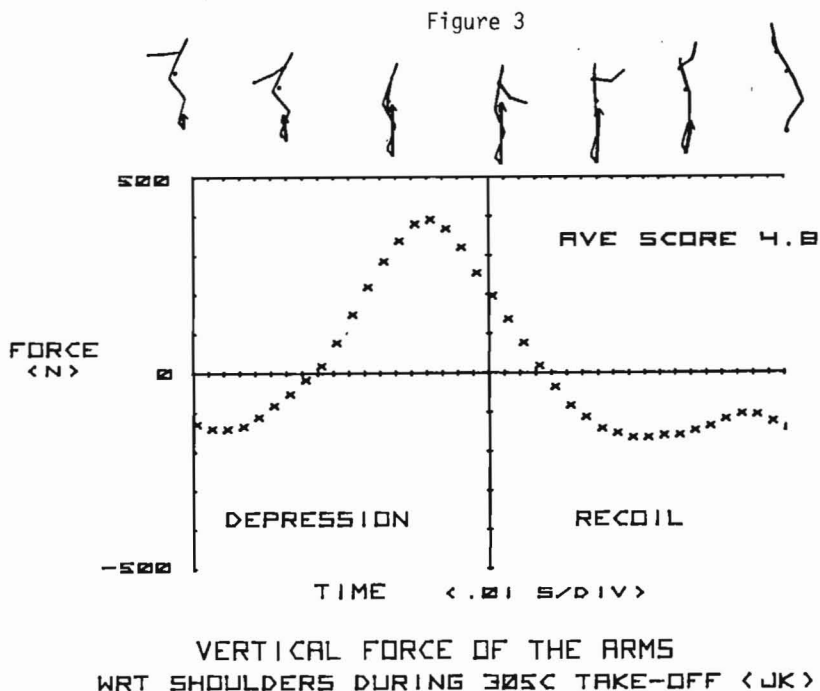
Velocity. Horizontal and vertical components of velocity at touch-down, maximum springboard depression and final contact with the board preceding the flight reveal differences specific to the dive being performed as well as providing a comparison with other competitors. Minimum and maximum values of these components when occurring other than at the three critical points mentioned also furnish valuable information on the mechanics of execution of the take-off.

Acceleration. Comparison of the vertical acceleration of the diver with that of the end of the board provides the basis for identifying the extent to which the diver is actively depressing the board (diver's acceleration greater) as well as the parts of the take-off during which the diver is "riding the board" (accelerations approximately equal) or absorbing some of the vertical force of the springboard (springboard acceleration higher than that of the diver). This type of display for the forward dive layout is indicated in Figure 2. In this example, the diver experienced excessive force absorption near the end of springboard depression. In the extreme, a sufficiently high force absorption would result in "killing the bounce" thereby eliminating the flight.



VERTICAL ACCELERATION OF DIVER AND BOARD
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Force. Because of the concern with the role of the arms in helping to depress the springboard, it seemed important to isolate their contribution to the total vertical force exerted by the diver against the board. This was done by subtracting the vertical acceleration of the shoulders from that of the center of gravity of the arms and then multiplying this relative acceleration by the mass of the arms. The plot of this relative vertical inertia force against time clarified the contribution of the arms. In the example shown in Figure 3, the diver was too late in initiating her arm swing so that the arms were still accelerating negatively with respect to the shoulders when contact was made. As a result during the first part of the take-off they were "absorbing" rather than contributing vertical force to depress the board. This type of display is particularly useful in dispelling the myth that upward motion and upward acceleration always occur together.



Springboard Reaction Torque. The torque or turning effect produced by the springboard reaction force (resultant as well as vertical and horizontal components) with respect to the center of gravity was plotted as a function of time throughout the take-off and was supplemented by superimposing arrows showing the magnitude and direction of the springboard reaction on the stick figure sequence. This type of feedback, reported previously (Miller, in press), revealed the interrelationship between horizontal and angular momentum and identified some potentially dangerous tendencies associated with attempting to maximize rotation in multiple somersaulting dives from the forward and backward groups.

Flight

The diver's velocity at the end of the take-off was used as the basis for predicting height achieved in the flight and horizontal distance of the diver from the board when at board level and also at entry into the water. This information was presented by dive with the values for the specific divers being ranked according to the average judge's score awarded for the dive.

CONCLUSION

For the type of feedback described to reach its potential value in terms of

direct application, coaches must be familiarized with its meaning and use. This could most effectively be accomplished through workshops with coaches and practitioners, workshops which stress two-way communication for the mutual benefit of all concerned. The CADA is presently being approached to explore the possibility of taking this second and most vital step.*

REFERENCES

Miller, D.I. Springboard reaction torque patterns during nontwisting dive take-offs. Biomechanics VIII (in press).

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