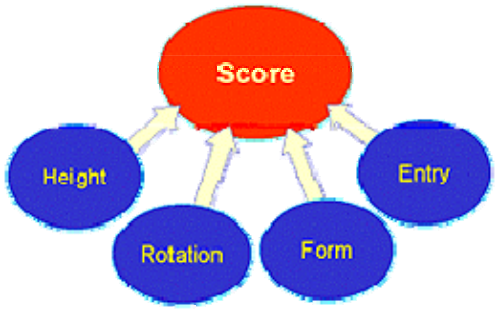

Why We Measure What We Measure

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- Introduction
- Height
- Rotation
- Common differences between good and poor divers

Introduction

There are four major aspects contributing to a successful dive:

- Height
- Rotation
- Form (aesthetics of the timing and postures adopted)
- Entry

The above are interrelated but we will discuss height and rotation separately for simplicity.

Height

Height attained in a dive has both direct and indirect influences on the dive score (McCormack, Subbaiah, and Arnold; 1982). Height in itself is a factor that judges take into account when judging a dive. Indirectly, it affects the rotation. The greater the height attained, the more time the diver has to complete the necessary rotations. The time that the diver has in the air also indirectly affects the form. Good divers complete the necessary rotations in sufficient time to prepare for entry in an unrushed manner and to enter the water with an aesthetically pleasing extended posture. Time in the air also allows the diver to create the appearance of not having to rush immediately after takeoff. The diver can adopt the dive position near the peak of flight instead of during and immediately after takeoff. This also contributes to the appearance of good form.

Miller and Munro (1984) and Sanders and Wilson (1988) have identified aspects of technique that are associated with height achieved in a dive. These aspects can be most easily understood by considering the energy exchanges that take place during the hurdle and takeoff in forward and reverse dives and during the preliminary bounce in backward and inward dives. Basically, the diver gains height by doing work on the springboard during its depression by extending the joints, particularly the hip and knee joints. Once this energy is in the system the diver must minimize absorption of energy in the muscles. Absorption of energy occurs when muscles are working eccentrically, that is, when the knee and hip joints are flexing. The guidelines for gaining height are:

- In forward and reverse dives, divers must maximize initial energy in the system by having a high hurdle. A high hurdle is achieved by extending vigorously at the ankles (termed 'plantar flexion' in anatomy and kinesiology texts), knees, hips, and flexing the shoulders (arm swing) during the depression of the board in the hurdle.

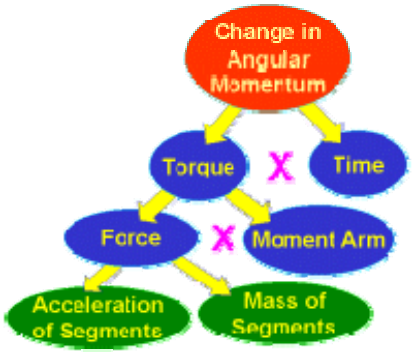
- When landing from the hurdle the diver must be flexed at the hips and knees. This gives the diver the ability to extend during the depression of the springboard to store additional energy in it. In backward and inward dives the diver must be flexed at the hips and knees at the start of the depression of the springboard.

- The diver should extend strongly at the hips and knees during springboard depression. Further, flexion following landing needs to be minimized to avoid absorbing energy.

- The diver needs to avoid flexion of the hips and knees prior to takeoff from the springboard. These actions also absorb energy. Some hip flexion is necessary in higher rotation dives to help produce rotation. However, the more skilled the diver, the less the hip flexion tends to be. Therefore, divers should seek to minimize hip flexion at takeoff while still generating sufficient rotation to perform the dive.
- In backward dives and reverse dives the same principles apply as described above. However, in the case of these dive groups the diver seeks to avoid excessive hyperextension of the hips. The diver should be extended at takeoff but not have a high degree of hyperextension.
- Energy is also lost by having too great a body lean at takeoff. In this case much of the energy is used to throw the diver towards the middle of the pool rather than in an upward direction.

In view of the above we are interested in:

- Hip and knee flexion at:
    - The instant of landing from the hurdle and at the start of final depression of the springboard in backward and inward dives.
    - The instant of minimum knee angle and hip angle during springboard depression. This minimum should occur close to the instant of landing and the difference in hip and knee angles compared to those at the instant of landing should be small.
    - The instant of takeoff from the springboard.
- The angle of lean at takeoff.
- The following times:
    - Hurdle time (the greater the time of being airborne the greater the hurdle height).



- Flight time (the greater the time of being airborne the greater the hurdle height).

Rotation

The quantity of angular motion (angular momentum) required for a given dive depends on:

- The number of half somersaults required.
- The time in the air available to complete the dive.
- The postures adopted during the dive.
- The time that the postures, for example pike or extended, are held.

To develop this angular momentum, divers rely on torques acting from the springboard. The change in angular momentum depends on the magnitude of the torque and the duration that it acts. Forces acting at the feet of the diver generate torque if they have a line of action that does not pass through the centre of mass of the diver. The torque is the product of the magnitude (size) of the force and the perpendicular distance of its line of action from the centre of mass of the diver. Because both the reaction force and the perpendicular distance (termed its 'moment arm') change during depression and recoil of the board, the torque changes in size and sometimes also in direction. The magnitude and direction of the force depends upon contributions from the diver's head, trunk, arms and legs. The contribution of each segment's contribution to the springboard reaction force depends on the magnitude of its acceleration relative to the springboard acceleration and it’s mass. Thus, a diver creates large forces and torques by accelerating body segments away from the springboard and this has the desirable effect of increasing rotation as well as height.

It is useful to think of the forces in terms of vertical and horizontal components. Horizontal forces acting towards the middle of the pool contribute to rotation in inward and reverse dives and reduce the rotation in forward and backward dives. Horizontal forces towards the middle of the pool have the unwanted effect of pushing the diver out from the board towards the centre of the pool. These forces are often large when a diver leans too far towards the centre of the pool. Horizontal forces acting from the end of the springboard towards the fulcrum of the springboard contribute to rotation in the desired direction for forward and backward dives and reduce rotation in reverse and inward dives. In forward and reverse dives these forces occur at hurdle landing to stop the forward motion accompanying the hurdle. Rather than changing hurdle lengths as a means of producing horizontal braking forces appropriate to the rotational requirements of the

dive, good divers keep their hurdle lengths consistent across dive types. Good divers also avoid large horizontal forces that 'throw' them out into the middle of the pool. Therefore, a major mechanism for control of rotation in dives is the position of the centre of mass with respect to the line of action of the vertical component of the springboard reaction force. In the forward and backward dives the diver leans towards the centre of the pool so that the line of action of the vertical reaction force passes behind the centre of mass. The angle of lean and the angle of hip flexion increases in forward dives with increasing rotational requirements. In backward dives the angle of lean and hip extension increase with increasing rotational requirements.

In reverse dives it is difficult to get the line of action of the vertical reaction force in front of the centre of gravity. Therefore, much of the rotation must be produced by the horizontal reaction force acting towards the middle of the pool. The horizontal force is increased near the time of takeoff by extending the hips and flexing the knees. This produces a horizontal reaction force acting against the feet. Because this has a large moment arm (distance from the line of action to the centre of mass), this force is effective in producing rotation in a short period of time. If this force acted for a long time then the diver would be pushed too far away from the board towards the middle of the pool.

A horizontal component of force must also make a substantial contribution to rotation in inward dives. This has the added advantage of ensuring that the diver moves away from the board so that the board is cleared despite rotating towards it.

With an understanding of how horizontal and vertical forces affect rotation, and recognizing that the rotational effect of the vertical forces is dependent on the angle of lean of the diver, an analyst is in a position to assess a diver’s performance with respect to rotation. One also needs to be aware that the angle of lean is partly dependent on hip flexion in the forward and inward dives and on hip hyperextension in reverse and backward dives. Thus, the following variables associated with the work done on the board are important:

- Hip flexion or hyperextension at the instant of takeoff from the springboard.
- The angle of lean at takeoff.

The amount of rotation is established at takeoff. Once contact has been broken with the springboard the diver's only control over the amount of rotation achieved is by the posture adopted while in the air. Divers rotate faster by bringing their body mass close to the axis of rotation (center of mass). Divers slow the rotation by extending to a straight position. Therefore, divers can control their entry angle despite having different quantities of angular momentum for a given dive. This is controlled by the timing of the changes in body posture from extended to piked or tucked (depending on the nominated dive position). However, it is important to have just the right amount of angular momentum at takeoff so that the postures adopted and their timing is aesthetically pleasing, thereby gaining a high score.

Signs of too little angular momentum are:

- Under-rotation at entry. That is, the dive is left 'short'.
- Extending late from the designated position (tuck or pike). Thus the entry looks rushed.
- Not being adequately extended at the time of entry.
- Adopting the designated position immediately after takeoff and appearing rushed to adopt that position.
- Traveling too far out into the middle of the pool in forward and backward dives (the horizontal force reduces the required angular momentum).

Signs of too much angular momentum are:

- Over-rotating at entry. That is, the dive is 'long' or 'washed over'.
- Not attaining and holding a tight pike or tuck position. The diver does not get as tight as possible and does not hold the position before extending.

The variables that provide an indication of the above are:

- Time of takeoff.
- Time of attaining maximum flexion.
- Hip angle at maximum flexion.
- Time of initiating extension.
- Hip angle at entry.
- Angle to vertical at entry.

Common differences between good and poor divers are:

- Good divers are characterized by good height and long time in the air.
- Good divers achieve the desired rotation with less lean at takeoff than poor divers.
- For a given dive, good divers have less hip flexion or extension at takeoff than poor divers.
- Good divers stay closer to the board.
- Good divers appear unrushed. This is manifest in:
    - Distinct delay between takeoff and adopting the designated position. Good divers adopt the position near the top of their flight.
    - Completion of somersault rotations while above the board. This provides enough time for extension to adopt a pleasing posture at entry.
    - Good divers have quick and precise transitions between positions.
    - Tuck and pike positions are held tightly with the head on the knees.
    - Good divers are well extended at entry even in high rotation dives.

Common differences between good and poor divers in twisting dives include those for non-twisting dives plus:

- Good divers minimize the use of a 'kick out' to initiate twist in forward dives. That is, the amount of hip flexion prior to extending to perform the twist is minimized.
- The twists are performed rapidly.
- The twisting rotation is completed in time to pike to stop the twist, remove the 'wobble' and extend for entry.
- Good divers have stopped the twist prior to entry, are aligned square at entry (left and right shoulders and hips are in line when viewed from the side) and have removed the tilt (when viewed from in front).

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