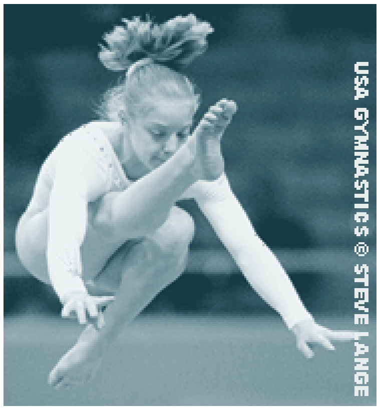
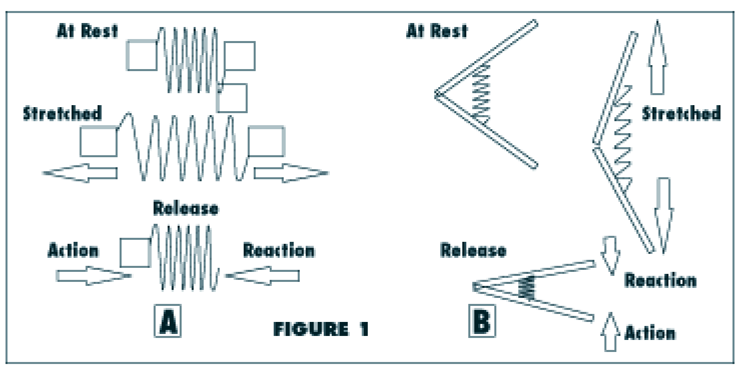
Action-reaction and Shape-jumps

By Wm A. Sands, Ph.D.



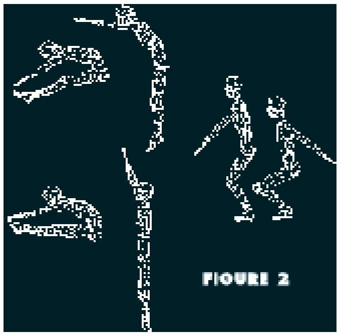
Perhaps one of the most commonly known but least appreciated laws of motion is Sir Isaac Newton's third law - Action-Reaction. This law roughly states that for every action there is an equal, opposite, and simultaneous reaction. We can read "action" as "motion" or force. Moreover, this deceptively simple law finds many applications in gymnastics, particularly in what I am going to call "shape-jumps." Shape-jumps are things like pike jumps, straddle jumps, and wolf jumps. These types of jumps seem to be much more prevalent currently than in the past, and they are often used in dizzying combinations. Recent experience has shown that athletes and coaches may not appreciate the role of the action-reaction law in the performance of these jumps.

Action and reaction refers to the idea that forces always work in pairs. When I push against the ground, the ground pushes against me - equally, in the opposite direction, and simultaneously. Most people understand this law as what they observe when two objects collide, or when a balloon is blown up and then released. These "linear" examples do not quite fully describe one of the more subtle and perhaps important aspects of action-reaction for gymnastics, that for every rotational action (i.e., torque) there is an equal, opposite, and simultaneous reaction (i.e., torque). The linear setting can be readily observed by pulling the two ends of a spring apart and then releasing them simultaneously (Figure 1a). The rotational setting can be observed by pulling open two pieces of wood hinged together and tensed by a spring and then releasing both pieces simultaneously (Figure 1b). These examples show the action-reaction law in a linear and an angular or rotational setting.



Because most motions of the human body are rotational in nature (e.g., elbow flexion, hip extension, etc.), the rotations of limbs about joints is similar to that shown in Figure 1b. Moreover, if the masses of the two objects rotating toward or away from each other are similar then we can count on both objects rotating about the same amount once the entire system (i.e., both objects) are free in space (in other words, the flight of the jump). The most common example of this phenomena is seen in a pike jump. Figure 2 shows two pike jumps. Because the masses of the trunk and legs are similar, the objects will tend to move about the same amount during the pike phase of the pike jump. This simply means that if you want the legs to rise to a certain height during the airborne phase of the jump, then the gymnast must lift the trunk to a certain position so that when both the legs and trunk move toward each other (due to action-reaction) their meeting place has the legs where you want them. In other words, if you want the legs to achieve a high position during the pike phase of the jump, the trunk must be raised to a near vertical position at the instant of take off.

Because the trunk will move toward the legs and the legs will move toward the trunk - the more stretched the trunk, the more the legs will move. Experience has shown that gymnasts tend to be incomplete in their stretch during take off, sort of anticipating the pike phase, and that gymnasts don't extend their legs fully on their jumps.



As gymnasts jump to make various shapes in the air, it is imperative that they be reminded to "jump fully" or "stretch tall" during the jump. The gymnast also needs to slightly separate the jump from the shape that the gymnast intends to make once airborne. These reminders should serve the gymnast to help her achieve greater virtuosity during these types of skills.

This article appears in the November/December 1999 issue of *Technique*,Vol. 19, No. 10.