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The springboard diving techniques analysis

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Abstract. The springboard diving techniques are involved the special characteristics of the springboard and the sport biomechanics of human movements. A good diving performance is depends on a good take-off, as to get a good take-off, it involves the diver's actions on the springboard. In considering the techniques for springboard divers, in the article, I will discuss the springboard special characteristics; the suitable actions for divers to co-operate with the board as the springboard goes down and up; where does the energy come from for the take-off; When the diver takes off as the springboard returns, at what point is the springboard at its highest speed; What are the factors influencing the time of the springboard going down and up；when the board returns, is the extension action useful or not; how can the divers choose the fulcrum; what kind of factors influence the divers loss of energy; Also I will discuss some other factors that are included in the springboard diving techniques, and give some advices for improving the techniques and training.

Key words: springboard diving techniques, take-off, hurdle

1. Introduction

Springboard diving techniques usually include the run, the hurdle, the take-off, the action in the air and entering into the water. A successful action in the air depends on a good take-off, this is why diving experts pay more attention to the take-off. So as to get a good take-off, we should know all the techniques on the board until the point of take-off. It includes the run, the hurdle, the ride down and the press. In this article I will consider the special characteristics of both the springboard and human movement, to analyze suitable techniques for springboard divers to have.

In considering the techniques for springboard divers, we need consider the divers actions on the board. As easy to discuss, it can be divided into two sections----bench and extension actions. But when should divers do bench and extension? It depends on both the human movement and the springboard characteristics.

In the article, I will discuss the springboard special characteristics; the suitable actions for divers to co-operate with the board as the springboard goes down and up; where does the energy come from for the take-off; When the diver takes off as the springboard returns, at what point is the springboard at its highest speed; What are the factors influencing the time of the springboard going down and up；when the board returns, is the extension action useful or not; how can the divers choose the fulcrum; what kind of factors influence the divers loss of energy; Also I will discuss some other factors that are included in the springboard diving techniques, and give some advices for improving the techniques and training.

2. The springboard special characteristics

For a springboard diver, the first thing she/he should know is to know the special characteristics of springboard. In this case, she/he can know how to use it. It is just like a rider, you have to know your horse well.

The basic springboard characteristic is that it can store energy. There is an energy transfer. When the diver press the springboard down, it stores the energy from the diver into the springboard (Figure1-1 to Figure1-2). When the springboard goes up, it returns the energy back to the diver (Figure1-2 to Figure1-3) and the diver can jump up. It is not like the platform diver, when during the extension the diver can get the force to help him/her jump up immediately. So for springboard divers, the springboard acts a "middle man". There is an energy transfer, when the springboard goes down, it stores energy from the diver into the springboard, when the springboard goes up, it returns energy from the board to the diver. Springboard divers should always remember this.

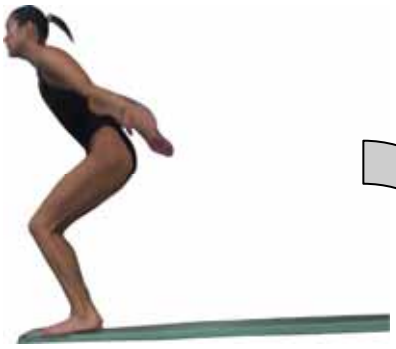

Fig1-1 the diver landing on the springboard.

The energy store in the springboard

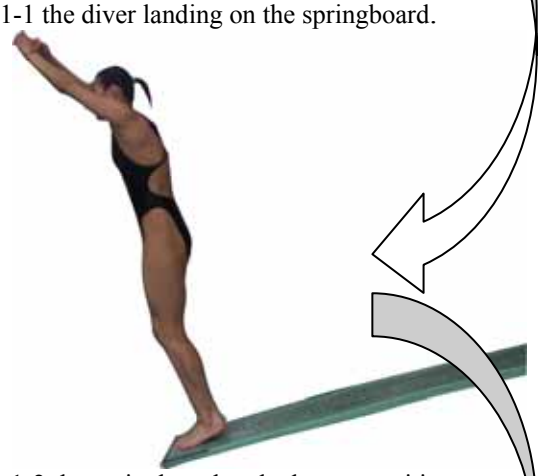

Fig 1-2 the springboard at the lowest position

The springboard returns the energy back to the diver

Fig 1-3 the diver leaving the springboard

3. When the diver takes off as the springboard returns, at what point is the springboard at its highest speed?

When the diver stand at the end of the springboard and doesn't move, the springboard go down a little from its horizontal position. We can call the distance δ_{st}, (Figure 2), it is influenced by the fulcrum the diver choose and his/her weight. At this point the diver's weight is equal to the springboard force. Under this point, the spring force is larger than the diver's weight, so the diver can get upward acceleration, the velocity of the springboard will increase. Over this point, the diver's weight is greater than the spring force and the diver get downward acceleration, the velocity of the springboard will decrease. So at this point the springboard has its highest velocity.

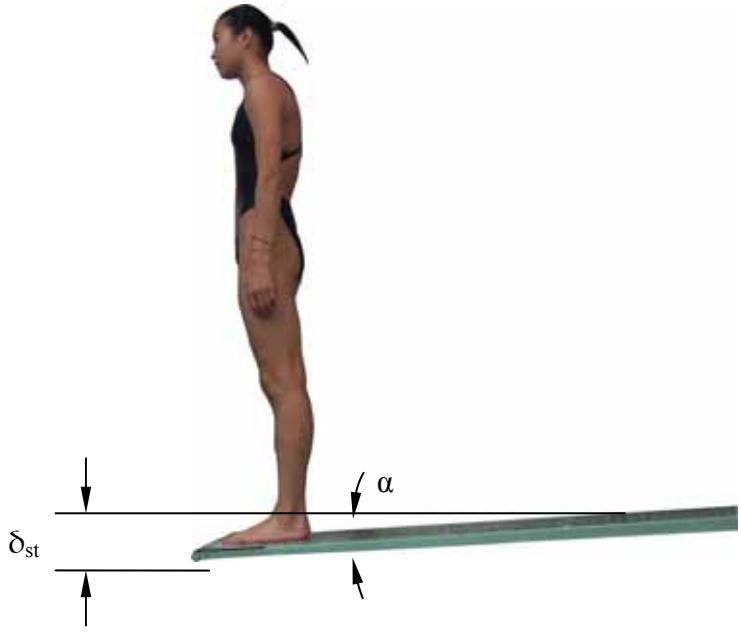

Fig 2 the diver stand at the end of the springboard and doesn't move

3. What are the factors influencing the time of the springboard going down and up?

Does the time increase as the distance of the springboard's movement increase when the fulcrum is not changed? Such a question can be expressed mathematically as:

$$T = \pi \sqrt{\frac{\delta_{st}}{g}} \tag{1}$$

Where T represents the time of the springboard going down and up, π is equal 3.1416, g is the gravity acceleration, δ_{st} is the distance of the springboard down from the horizontal position when the diver stand at the end of the springboard and doesn't move.

In the equation, we can see, g and π are not changed, δ_{st} will be varied by the fulcrum and weight change. In fact, for one diver, we could consider that the weight does not change. So the time of the springboard going down and up will be changed only when the fulcrum changes. It does not depend on what distance the diver press the springboard. If the δ_{st} is the same, when the diver press the springboard down more, she/he can get a higher speed when she/he leaves the springboard. The time of the springboard going down and up will be the same as when the diver presses the springboard less.

4. Where dose the energy come from for the take-off?

How can the springboard help the diver to improve the height of the jump? To answer this question, we should begin with analyzing the hurdle.

For the hurdle, there is a single leg take-off. As I said before, it involves the transfer of energy. When the diver extends and presses the springboard down, the energy is stored in the springboard. When the springboard returns, it returns the energy back to the diver. So the diver can leave the springboard and jump in the air, but in this case, by using the springboard in this way, the diver can not improve the height of the jump.

From the hurdle landing to the end of the springboard, suppose that the diver makes no movement, i.e. keeps the body straight. What will happen? The diver can store the energy from the hurdle in the springboard, press the springboard down, when the springboard going up, it returns the energy back to the diver and the diver can jump into the air again. This is because the springboard can store the energy and repay it back to the diver, but it can not improve the height of the jump. If after the landing from the hurdle, the diver dose an extension, the springboard can be pressed down more. The springboard not only stores the energy from the

hurdle, but also stores the energy from the extension (Figure 4-1). When the springboard returns, it repays all the energy to the diver at once time (Figure 4-2).

So the energy for the take-off, not only comes from the extension during the take-off, but also the energy from the hurdle is added. The springboard stores two lots of muscle work, but repays it back to the diver in one lot. That is why using the springboard can improve the height of the jump.

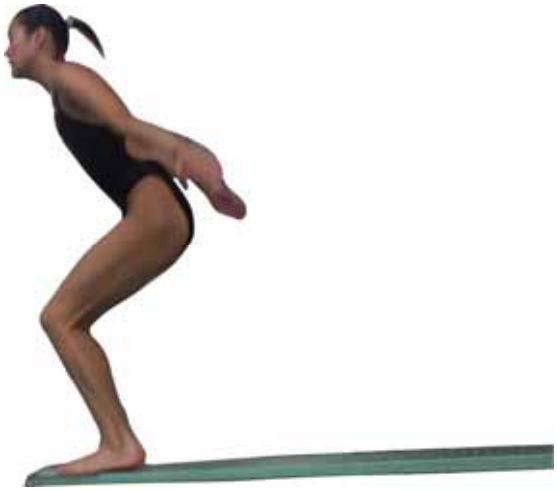

Fig 4-1 the energy from the hurdle and extension store in the springboard

Fig 4-2 the energy from the hurdle and extension return to the diver

5. When the springboard returns, is the extension action useful or not?

As I have analyzed before that when using the springboard, the energy is stored in the springboard first. After that, when the springboard returns, it can repay all the energy back that the diver has stored in the springboard. But as the springboard returns, the diver dose the extension, the energy can not be stored in the springboard, is this still useful for the take-off?

First suppose there is no extension movement during the springboard returns. It can be expressed as:

$$F - mg\cos\alpha = ma \tag{2}$$

Where, F is the spring force. mg is gravity. α is the angle of the springboard and horizontal direction. a is the acceleration by spring force and gravity.

Then suppose there is an extension movement during the springboard returns. If the coordinate on the springboard is fixed, it can be expressed as:

$$F'-mg\cos\alpha - mw = ma_1 \tag{3}$$

Where, *F'* is the spring force. *mg* is gravity. α is the angle of the springboard and horizontal direction. *w* is the acceleration of springboard. a_1 is the acceleration of center of gravity for the springboard. If equation (3) is written as:

$$F'-mg\cos\alpha = m(a_1 + w) \tag{4}$$

When both α are equal, compare the equation (2) and equation (4), the springboard is at the same point, the spring force are equal:

$$\therefore F = F'$$
$$\therefore a = a_1 + w \tag{5}$$

In equation (5), the L.H.S. of the equation is the centre of gravity acceleration with no extension, and the R.H.S. is the centre gravity acceleration with extension. So with or without the extension, there is no change for the centre gravity acceleration. That means, when the springboard returns, the extension action is useless. The diver should finish the extension when the springboard at the lowest position (Figure 5).

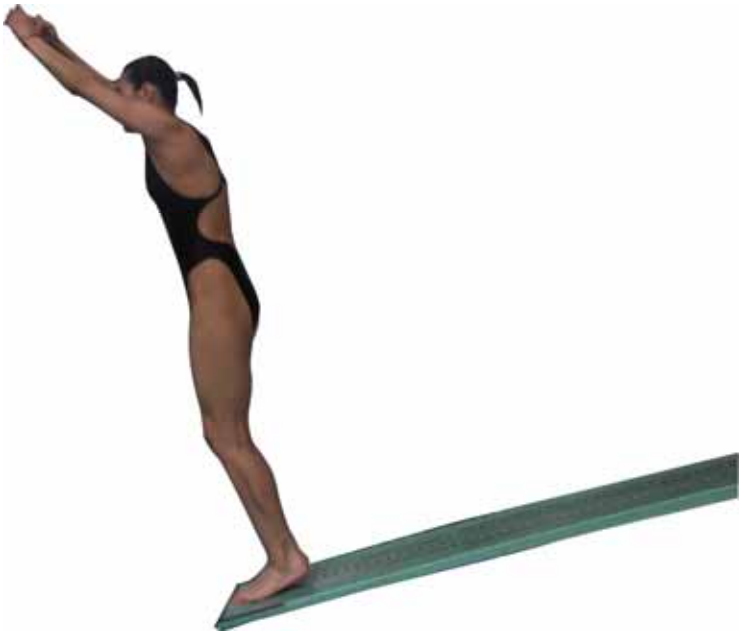

Fig. 5 the diver should finish the extension at the lowest position

6. How can the diver choose the fulcrum?

How does the diver choose the fulcrum? What kind of factor influences their choice? It seems hard to answer. Let us discuss from the situation when the springboard starts to returns. It can be expressed as:

$$F = ma + mg\cos\alpha \tag{6}$$

Where, F is spring force. mg is gravity. a is centre of gravity acceleration. α is the angle of the springboard and horizontal direction. In such a situation, the springboard will return. It does not depend on the diver's wish what it does. As I have analyzed before, to use the springboard efficiently, first the energy should be stored in the springboard. When the springboard returns, the extension movement is useless. So according to the diver's weight, the angles of joints at the start of the extension, muscular force and the time taken to start of the extension, the fulcrum should be chosen when the springboard at the lowest position and the diver can finish the extension. In that case, the diver can store his/her energy in the springboard. Of course, the springboard will return all the energy back that the diver had stored.

7. What kind of factors influence the divers loss of energy?

People like things that are active. For sports, they pay more attention to how they can get more force. But

at the same time, they may ignore some movements that cause the loss of energy.

From the hurdle to the landing at the end of the springboard, the diver has two purposes. One is to store the energy from the hurdle into the springboard, the other is to do an extension to store more energy into the springboard. Usually, at this time, divers only think how to extend. They ignore the action before the extension.

For landing, there are two different ways. The diver can bend at the hip and knee joints before or after the feet touch the springboard. Is there a difference between the two ways of landing? To answer this question, we could think of another simple example. You do the landing from the hurdle twice. Once after the landing, keep your body straight and without any bending, the other after landing you bend at your hip and knee joints. It is easy to get the answer. After landing, without bending you can still jump in the air. But with bending you can not jump in the air. So after landing, any bending will case the loss of energy.

In springboard diving, landing occurs twice at the hurdle (Figure 7-1) and take-off (Figure 7-2). So pay more attention to landing, the diver should not do any bending after landing, that cause loss of energy that she/he has.

Just like the landing, for the take-off, when during the springboard returns, it will cause loss of energy by earlier movement of the body from the vertical position as well as any bending movement. For getting angular momentum, the diver should move the body from the vertical position, but most divers move their body too early, it cause loss of energy as well as leaving the springboard earlier. When the springboard returns, the diver accepts the energy from the springboard that she/he has stored. The diver should not waste any energy that they have got by moving the body too earlier and leaving the springboard earlier.

Fig 7-1 Landing from the hurdle

Fig 7-2 Landing from the take-off

8. Conclusion

For the take-off, the energy comes from two extensions during the hurdle and the take-off. So we should pay attention to the hurdle as well as the take-off. During the hurdle and take-off, there are two landing, the diver should bend at the hip and knee joints as the angles prepare to extend before the feet touché the springboard. After the feet touché the springboard, any bending movement will cause loss of energy. For the hurdle and take-off, the two extensions should be finished when the springboard is at the lowest position. In that case, the energy could be stored in the springboard and the diver can use their energy efficiently.

When the springboard returns, the highest return speed of the springboard is at the position when the diver stands at the end of the springboard and does not move. It depends on the diver's weight and the fulcrum that the diver chooses.

For choosing the fulcrum, the most important factor is that the diver can finish the extension when the springboard is at the lowest position. It is also influenced by the diver's weight, muscular force, the joints angles to start the extension and the time to start the extension.

The time of the springboard going down and up is depends on (the position when the diver stands on the springboard and does not move). Is influenced by the diver's weight and the fulcrum she/he chooses. So only these two factors influence the time of the springboard going down and up.

For the take-off, when the springboard returns, the diver should move the body from the vertical position as late as position. The ankle joint extension should start at the position of the springboard where the highest speed is reached. i.e. the springboard position when the diver stands on it and does not move.

9. Some advice

To improve techniques

- Roll the fulcrum back, make the springboard more "soft"
- Change the hurdle near the end of the springboard, make the hurdle smaller
- Avoid any bending movement after the feet touché the springboard
- Finish the extension when the springboard is at the lowest position
- Emphasize the arm swing earlier, it can help to start the extension earlier, and finish it when the springboard is at the lowest position
- Increase the step width and height before the hurdle, it can help to increase pressing the springboard and store more energy for take-off
- For training
- Strengthen the run, hurdle and take-off stable training, it is more difficult especially when the hurdle becomes smaller
- Strengthen the precise point of landing for hurdle and take-off training, because changing the point of landing will cause the time of the springboard going down and up to change
- Strengthen static force training at the position where the extension starts, it can help avoid buffers during landing
- Strengthen the ankle force training, especially the capability of fast extension, it can help to increase the velocity of leaving the springboard

10.Reference

[1] Qining Wang. China Sport Science and Technology. 1985, **8**(1): 26-32.