

Hit the Springboard!

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We agree that modern vaulting would be impossible without hitting the vault board. The problem is “how to hit the board for the best possible vault?”. Looking at the number of balks in training and competition, this is obviously not easy to do, and a big training problem.

Faster IS better.

First of all, we want to hit the board sprinting as fast as possible. Naundorf and co-workers (2008) reported that there had been an important increase in vault sprint speed between World Championships in 1997 and 2007, by both men and women, even though these were some of the best vaulters in the world. Then Schärer and co-workers (2019) did a huge job collecting data from 494 vaults during the 2016 European Championships. 89 elite men, 89 elite women, 123 junior men, and 106 junior women vaulted. In other words, this data is from four groups of high performing gymnasts from many different national teams. 51% of womens' vaults were Yurchenko-style vaults, 24.5% were handsprings, and 24.5% were Kasamatsu/Tsukahara vaults. 69% of the men performed Kasamatsu/Tsukahara, but only 19% handsprings and 12% Yurchenkos. Women prefer Yurchenko style vaults and few vault handsprings or Kasamatsu/Tsukahara vaults while men greatly prefer Kasamatsu/Tsukahara vaults and few do Yurchenkos.

In those 2016 European Championships men hit 8–9% faster peak sprint speeds than women during handspring and Kasamatsu/Tsukahara vaults, but had similar speeds vaulting Yurchenkos. Elite men sprinted faster than junior men vaulting handsprings and Kasamatsu/Tsukaharas. Vaulting Yurchenkos, elite women reached faster sprint speeds than junior women. Women's sprint speed correlated significantly with both difficulty (D-) score and height of flight, for all types of vaults. Men's sprint speed correlated significantly with the D-score, height, and length of flight, but only of Kasamatsu/Tsukahara and Yurchenko vaults, not vaults like the Roche or Dragulescu. In conclusion, more difficult vaults by women require faster sprint speeds than vaults with lower D-scores. Therefore, within this range of speeds, the faster the sprint, the better, regardless of vaulting style. Men may not need to sprint as fast as they can, even for the most difficult vaults (Schärer et al., 2019). This remains an open question.

We do not know how sprint speed and score correlate at lower levels of performance, for example Junior Olympic Levels 2-5, but we can guess based on research that at this level, sprint speed at board strike is one of many factors that are highly related to performance, unlike at the elite level. Mathematically, vault sprint speed and D-, E-, and Final-scores of international junior and elite women were more highly correlated than mens in the 2016 European Championships. Among juniors, relationships between sprinting speed and the other measured parameters tended to be weaker than in the elite levels. Therefore, to successfully progress from junior to elite level vaulting, sprinting speed must improve, increasing flight time and height,

and consequently, a potentially better landing. This requirement is more important for women than men (Schärer et al., 2019).

Sprinting speed is basic for the vault event. The reason for the relationship between sprinting speed and D-score is that during take-off from the springboard or vaulting table, horizontal kinetic energy accumulated during the sprint is converted into flip and height (angular and vertical kinetic energy), making the second flight phase. Consequently, the goal must be to hit the board with the highest possible speed, not just an optimal speed. The possible exception of men vaulting handspring entry type vaults (eg. Roche or Dragulescu). Hitting the board at high speed also makes it possible for the gymnast to use a stiffer, faster springboard with more springs, potentially gives a bigger, stronger reaction that can be used for a bigger first and second flight.

Variations During the Sprint

Measurements of the individual sprinting strides of some of the best vaulters in the world, even in actual competition, for example Olympic and World Champion Marian Dragulescu, clearly show that they are adjusting their strides during the sprint (Trillhose, 1995; Veličkovic, et al., 2007; Heinen et al., 2011). Even if they think they are doing something else, they are also adjusting their strides to hit the springboard at highest possible speed. Measurements of sprint time during an entire vault practice show a variation in times, and therefore speeds, attempt to attempt, even for the same gymnast. This can only happen with variations in stride length and frequency, but vaulters can still hit the springboard relatively consistently during a practice. Consequently, stride length and stride frequency, or both at the same time, are in reality changing vault attempt to vault attempt. All gymnastics coaches have observed novice vaulters adjust their stride length to hit the springboard. The result is often a visible-with-the-naked-eye slowing down of their sprint speed. World class vaulters are also adjusting their sprint stride length and frequency during their run, but to increase sprint speed to the springboard strike.

We should also expect that a gymnast's sprinting ability will vary from practice to practice: some days more energetic, some days more fatigued. Even during vault practice, the legs will not be as fresh at the end as at the start of vaulting. Both the stride distance as well as the stride frequency could vary, and probably will. If the gymnast is focused on changing some technical element of the vault, or is attempting a vault that is very difficult for them, we must expect their strides to be different from when they were focused on maximum speed. If a gymnast attempts to vault with the same number of steps, over the same sprint distance to the board every vault, he or she must necessarily sprint at that speed when they are slowest, most fatigued, or least focused on sprinting fast. Logically, that is the only way to be consistent because by definition maximum speed will vary. Therefore, as soon as gymnasts count steps or distance in order to consistently hit the springboard, they must run at sub-maximal speed. In fact, many gymnasts run slower than they could in order to consistently hit the springboard, trading speed for consistency. They vault with a stereotyped, slower than possible run, for example with a consistent number of steps. But faster is better. How to solve this problem?

Target Directed Running

Fortunately, hitting the springboard belongs to a family of human activities called target directed running that has been studied by physiologists for some time now (Davids et al., 2005). Scientists have studied track-and-field long and triple jumps, cricket bowling, and vaulting as examples of a task that is solved by humans to learn about basic human physiology.

Advanced gymnastics skills require a precise interaction between the gymnast and the environment. Experimental evidence suggests that visual information controls gymnastics vaulting (Heinen et al., 2011, 2017). There is no evidence of a stereotyped approach run with a standard number of steps. The action of running towards the springboard brings about changes in the approach run and handspring kinematics that relate directly to the position of the springboard. When the position of the springboard was changed in experiments, the data showed that the feet of expert gymnasts hit the springboard in the same place, adapting to the springboard position during the last three steps of the sprint. Springboard distance closer to the front edge of the vaulting table resulted in a different hand placement on the vaulting table, a shorter first flight phase, a take-off angle closer to 90° , and a longer second flight phase. Findings from these investigations and others suggest that the position of the springboard is a relevant source of information in gymnastics vaulting.

Yurchenko-type vaults, where the gymnast performs a round-off before contacting the springboard, bring yet another level of complexity because the round-off requires hurdling off the same leg every time. Heinen and co-workers (2017) ran experiments moving the round-off mat and the position of the springboard. They wanted to understand how different environmental cues act and interact in the control of complex skills. Kinematic data from eight female expert gymnasts' Yurchenko timers were recorded in a baseline condition and two experimental conditions moving the round-off mat and the springboard closer or farther from the table. Results revealed that visual control of the sprint occurred in average two steps prior to the hurdle. Hand positioning on the round-off mat preceded a constant round-off flight phase. Gymnasts placed their feet on average on the same spot on the springboard, regardless of whether the springboard position was moved closer or farther from the table. Finally, hand placement on the table varied mainly as a function of the position of the springboard and the distance of the first flight phase to handstand on the table. These results are evidence that the position of the round-off mat and springboard control the sprint of Yurchenko-type vaults (Heinen et al., 2017).

Research suggests that at the very least, gymnasts are using what they see to adjust their strides during their sprint. This is the case even for the Yurchenko vault that requires a hurdle off a certain leg. We can even guess at the physiological mechanism: focused on the springboard, or round-off pad in the case of Yurchenko vaults, the size of the target on the back of the eyeball (retina) grows as the vaulter approaches the springboard. Not only can the brain perceive this information, Koch (1999) has shown how neurons in the brain can chemically perform differential calculus and then communicate to other parts of the brain how fast the

board is approaching, its rate of change of distance. This information is then used by the experienced vaulter to adjust stride length and frequency to hit the target, the springboard, without a stereotyped number of strides, at the highest possible speed.

Practical Recommendations

- From the first attempts to vault, gymnasts should be taught to look at the springboard until the hurdle step. Focus visual attention on the springboard as a target, instead of the floor or the table for example. This is analogous to learning to drive a car where the beginner must learn to look down the road instead of at the front of the car. Some coaches place a line to mark the desired hurdle point. But what is more important, hitting a hurdle line, which may change on how fast the gymnast is actually sprinting at that instant, or hitting the board? The gymnast's attention should be directed at the board.

- Novice vaulters should practice sprinting to the springboard through an "obstacle course" of cones, foam blocks, or noodles, in addition to common vault practice, to develop the ability to adjust stride length and frequency to hit the springboard.

- When the gymnast has become a reasonably strong sprinter, use the entire 82 ft. of the legal vault runway so that the gymnast can make adjustments during the sprint and still have room to accelerate and hit the spring board at maximum speed.

- Faster is better. Therefore time the gymnasts' sprint during vault practice often. For example, use a simple, relatively inexpensive and easy to set up and take down wireless infrared photocell timer. Pictured is the springboard end of the Tractronix dual beam system, accurate to 1/100 second:



Coaches need the information and gymnasts need the feedback. In particular for women, the coach must know that sprinting speed has increased before teaching a more difficult vault.

- When attempting a round-off or front handspring entry vault, the visual target of the gymnast should be the vault pad during the entire sprint and hurdle.
- Start the sprint slowly, progressively increasing stride length and frequency, and thereby sprint velocity steadily, attaining maximum horizontal velocity at board strike, to facilitate smooth adjustments of stride length and frequency.
- The first mesocycle training a high difficulty vault should have lots of maximum speed sprints, board strikes, and double backs or fronts without the table in place. This is to develop the ability to hit the board at high speed without having to deal with the table. Then, once the gymnast is able to hit the board at high speed consistently, the table can be added.

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