MEASURING WORKLOAD IN FIGURE SKATING

BY LINDSAY HANNIGAN

Defining *workload* in sports has been a hot topic for the past two decades as athletics have moved away from a work-harder mentality to a work-smarter mentality.

There are a variety of wearable devices in traditional running sports, such as soccer, basketball, football and rugby, to measure workload. These more traditional sports often use distance covered (e.g., number of steps taken, miles run) and we have learned that the greater the distance covered, the higher the workload.

Although we have benefitted from the knowledge in these sports, figure skating is a completely different activity requiring a different type of exertion. Rather than running down a field or court as fast as possible, our athletes are rotating up to 2500 degrees/second in the air for less than a second to complete triple and quadruple jumps. In the past, we often defined *workload* as the total number of jumps attempted during a training day. However this was based on the assumption that all jumps are equal.

All jumps can be considered equal in one category — vertical loading. (Vertical loading are the forces directly upward through the body without consideration for rotation.) It doesn't matter if you're doing a double or a quadruple jump, the body experiences a similar vertical loading. We tried monitoring total jump counts to limit the vertical loading, but did not see a significant reduction in injuries in figure skating. This led to the investigation of rotational speed during jumps. Understanding the rotational demands during training is important because figure skaters don't just jump up and down but need to rotate quickly for clean jumps. It is difficult to monitor rotational speed during training because many wearables are not capable of capturing the high speeds of figure skating.

After receiving a scientific grant from the United States Olympic and Paralympic Committee Technology and Innovation Advisory Board in 2019 to quantify rotational speeds in figure skating, we partnered with 4D Motion Sports, Inc. to create a skating-specific wearable device on the hip to measure rotational speed.

This was no easy task, especially in the middle of a global pandemic. It required months of virtual data collection and engineering support to refine the algorithm to identify the exact time when an athlete started and finished the jump. Through trial and error, we were able to identify the threshold for rotation speed for jumps and could use the hip speed of rotation to identify when the athlete started and ended the jump. The algorithm allowed us to get an accurate count of the number of jumps an athlete was completing during training, provided us with a breakdown of the doubles, triples and quadruple jumps attempted during training, and calculated the average rotation speed during training.

Fast forward four years of hard work and now we can provide our athletes with measures of workload specific to their sport using the 4D Motion Sports wearable. Using both the angular velocity (speed of rotation) and the total jumps performed each day, we can calculate a skating-specific measure for our athletes and sports performance and medical staff to help monitor health and progression (Figure 1).

In the monthly training in Figure 1, the athlete had an average rotation speed of approximately 1725 degrees/second. Some days, the athlete rotated faster or slower based on a variety of factors (e.g., what jumps they were working on that day). Interestingly, workload doesn't always correspond just to the rotation speed. In Figure 1, it's clear that when the athlete was rotating slower than average (days 11 and 12 of training in red), workload was highest (week 3 workload). This is concerning because the athlete was rotating slower than normal but was attempting more jumps than usual. In this case, the two training days in red are when the athlete is most likely to become injured, from the combination of slower rotation speed and increased jump attempts.

We have dedicated so much time and so many resources into sport science and medicine initiatives in our effort to continue providing our athletes with the highest standard of care and the most updated performance metrics. This sensor is also available for public purchase through 4D Motion Sports, Inc. at https://4dmotionsports.com/figure-skating/.

Dr. Hannigan received her PhD in sports medicine from the University of Virginia where she evaluated biomechanical and strength adaptations following anterior cruciate ligament reconstruction before and after high-intensity exercise. Following the completion of her PhD, Dr. Hannigan worked as a postdoctoral fellow at the Shirley Ryan AbilityLab (formerly known as the Rehabilitation Institute of Chicago) in the Center for Bionic Medicine. In her postdoctoral training, Dr. Hannigan predominantly worked with individuals with lower limb amputation. Dr. Hannigan serves as the sports sciences manager for U.S. Figure Skating, where she works with an interdisciplinary team to support peak athletic performance and return-to-skating plans following injury.

One athlete wore the wireless sensor during a month of training. The average rotation speed for each day of training is represented with a blue circle, and the average rotation speed over the entire month is represented with a dashed black line. The workload for each week of training is represented with gray squares. The two red circles demonstrate the two days when rotation speed was low, but workload was high, indicating a potential high risk of injury.