

On the Ball: The U.S. Bowling Congress



The U.S. Bowling Congress relies on bowling robot E.A.R.L., above, and other specialized equipment to conduct reliable research. To analyze their data, they trust Minitab Statistical Software.

KEY FACTS

ORGANIZATION

U.S. Bowling Congress

OVERVIEW

- Governing body for amateur bowlers in the U.S.
- Serves more than 2 million members
- Works with 3,000 local organizations

RESEARCH CHALLENGE

Determine the effects of static weight on bowling ball motion.

PRODUCTS USED

Minitab® Statistical Software

RESULTS

- Designed experiments made it easy to test multiple variables quickly.
- Analysis revealed new phase of ball motion.
- Data demonstrated the need to retain existing specifications.

Some 70 million Americans take to the lanes each year, making bowling the fifth most popular sport in the United States. More than 2 million people are U.S. Bowling Congress-certified league bowlers, and they take their sport very seriously: their high-performance bowling balls can cost \$300 or more. The U.S. Bowling Congress (USBC) strives to make sure that ball specifications and regulations keep the game fair and protect the investment players make in their balls. One such specification concerns “static weight,” which affects the balance of the ball and is measured between the finger and thumb holes, between the left and right sides of the ball, and between its top and bottom. After USBC research showed that current static weight values showed only a minimal effect on ball motion, many bowlers, pro shop operators, and manufacturers argued against static weight regulations. Contending that today’s bowling balls are affected more by ball dynamics and cover stock chemistry, they called for increasing the maximum static weight allowance or eliminating the specification altogether. The argument was compelling, but changing a sporting regulation is not a decision to be made lightly, so USBC research engineers undertook a project to more precisely assess how much static weight affects ball motion. They trusted Minitab Statistical Software to help design an effective and efficient experiment, and to analyze the data they gathered.

The Challenge

In November 2010, the USBC research team—led by USBC Research Engineer Nicki Mours—began

testing static weight at the USBC’s International Training and Research Center in Arlington, Texas. The facility had specialized equipment for assessing ball motion, including a bowling robot named E.A.R.L. (Enhanced Automated Robotic Launcher), and a highly sophisticated, computer-aided tracking system known as Super CATS. The research team needed to gather data with these tools that would let them assess and then model the effects of static weights on ball motion. They decided to assess the impact of top/bottom weight; left/right side weight; finger/thumb weight; ball speed; revolution rate; and intermediate differential. Their response variables included the intended ball path at 49 and 60 feet; average ball path at 49 and 60 feet; ball velocity decrease at 49 and 58 feet; angle change at 48 and 58 feet; first and second transition points; positive and negative slope; total hook length; angle per foot; “A” score; breakpoint; first and second transitions to the breakpoint; and frictional efficiency.

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For each factor, the researchers identified low and high levels that exceeded the current static weight specifications, but were not unreasonable to find in newly-purchased balls.

How Minitab Helped

The team had identified six distinct factors to assess. Testing each factor one-by-one would be prohibitively expensive and time-consuming, so Mours and her team used Minitab Statistical Software's Design of Experiment (DOE) capabilities. DOE reduces the number of runs needed to gather reliable data, making studies less expensive and more efficient. In a designed experiment, investigators can change more than one factor at a time, then use statistics to determine which ones have significant effects on an outcome.

The USBC engineers used Minitab to create a six-factor half-fractional designed experiment consisting of 32 test runs. Each run used a combination of factor settings. Two specially-constructed bowling balls were used for the test runs, one with a symmetrical core and another with an asymmetrical core. Each run was conducted on the same lane, with strict controls to hold ambient temperature, lane surface temperature and room humidity consistent.

After gathering the data, Mours and her team used Minitab to analyze it, obtaining an average of the shots and graphing the ball path. They also got a big surprise. Previous research had identified three distinct, mathematically predictable phases of bowling ball motion, and static weight appeared to have very little effect on these phases. But analyzing the newly collected data with Minitab revealed that a ball's static weight could result in a previously unidentified fourth phase of motion.

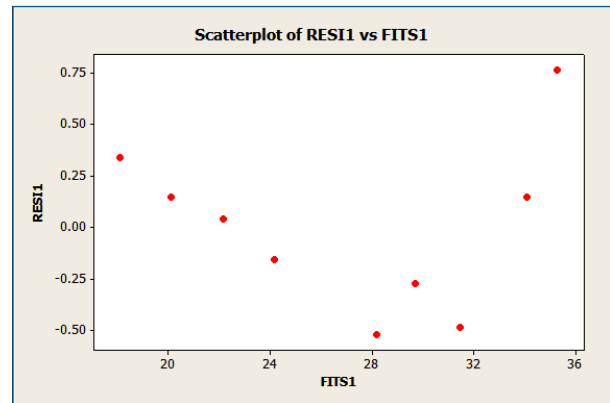
The researchers conducted a second designed experiment to better understand the practical impact of static weight and this newly-discovered fourth phase of ball motion. Using Minitab, they created a response surface DOE comprising 15 runs. A response surface design allows researchers to model curvature in a response, making this type of experiment very useful for seeing precisely how changes in input variables influence a response. For this set of runs, the researchers used simple ball drilling techniques to put a commercially available bowling ball a full 2 1/8 oz. over the USBC limit. Since this was a scenario that could easily occur in a bowling pro shop, USBC researchers wanted to know if the fourth phase of ball motion occurred at any one of six possible static weights.

Results

After Mours and her team analyzed the results of the second experiment, they concluded that if the current USBC static weight limits were eliminated or increased, the typical three-phase motion of bowling balls as they travel down a lane would be significantly altered, and the unpredictable fourth phase of motion would result. Given this additional knowledge, the USBC decided to retain the current specifications for static weight limits in approved bowling balls. If static weights were unregulated, static weight parameters could be combined to increase a bowling ball's entry angle into the pins through no additional skill of bowlers. Single-pin or right-side spares could be converted by using a ball with static weight characteristics that redirect the ball toward the pins.

"Our research proved that the current USBC static weight limits are still valid, even in this age of high-tech bowling balls," says Neil Stremmel, managing director of USBC's National Governing Body.

Meanwhile, Mours continues to conduct additional research on static weight and many other factors that can affect a bowling ball's performance, trusting the power of Minitab to help her analyze the data she collects. "Ultimately, our goal is that once a bowler purchases a ball that has been approved by USBC, there is no possibility for a pro shop operator to drill a ball through standard drilling processes and make the ball illegal," she says.



Often the fourth phase of ball motion could only be determined by examining residuals from the regression analysis. Residuals should roughly follow a straight line; Minitab graphs like the residuals vs. fits plot above made it easy to detect quadratic patterns in the data—patterns that revealed this previously unknown phase.