2023
STRING PINSETTER
SCORING RESEARCH
REPORT

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OVERVIEW

Since the announcement of the final specifications for string pinsetters, USBC has conducted an additional scoring project on the scoring pace of string pinsetters that meet USBC specifications. The study consisted of gathering volunteer bowlers to travel to the ITRC in Arlington, Texas, to bowl a set of four games – two games on string pinsetters and two games on free-fall pinsetters. Over 500 bowlers participated in the study, including over 300 bowlers that participated more than once. The data indicates that:

- There was no significant difference in scoring between the pinsetters used.
- The test had sufficient statistical power to identify a difference of four pins or larger had it existed.
- An average conversion between the pinsetter types will not be necessary.

Therefore, as next steps:

- Effective immediately, USBC will allow for the averages between the pinsetter types to be interchangeable.
- USBC will also continue to monitor averages in centers converting to string pinsetters to ensure data returning from the field matches what we have found in our research.

Background

As a continuation of previous research, the USBC equipment specifications staff has been conducting additional research into the use of string pinsetters using a new scoring test to evaluate the scoring pace of machines that meet specifications. Previous research that focused on USBCs automated Bowlscore ramp showed that the strike profiles of the string pinsetters were narrower than the strike profiles of the standard free-fall control set.
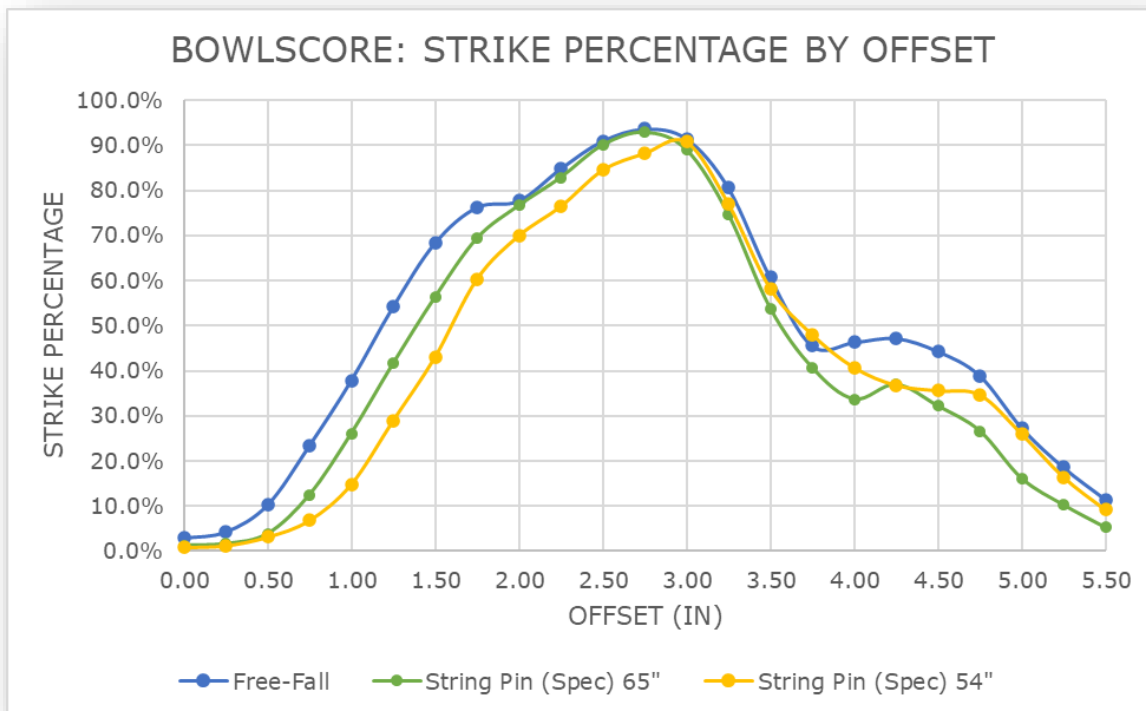
Utilizing this data as well as other scoring related data sets, it was estimated that scoring could be as much as 10 pins different on average. To investigate further, we designed a test that would provide enough data to definitively tell if the machines score differently or not.

Based on studying the paired difference in scoring between free-fall and string pinsetters observed in other tests that were conducted, it was determined that a sample of 350 bowlers bowling four games each on both pinsetter types would result in a data set capable of detecting a difference as small as three pins in average. Any differences smaller than that would be insignificant compared to the known variances between centers and league types and would not justify the need for a conversion.

Power Curve for Paired t Test

Sample Size: 350

Assumptions
α: 0.05
StDev: 17
Alternative: ≠
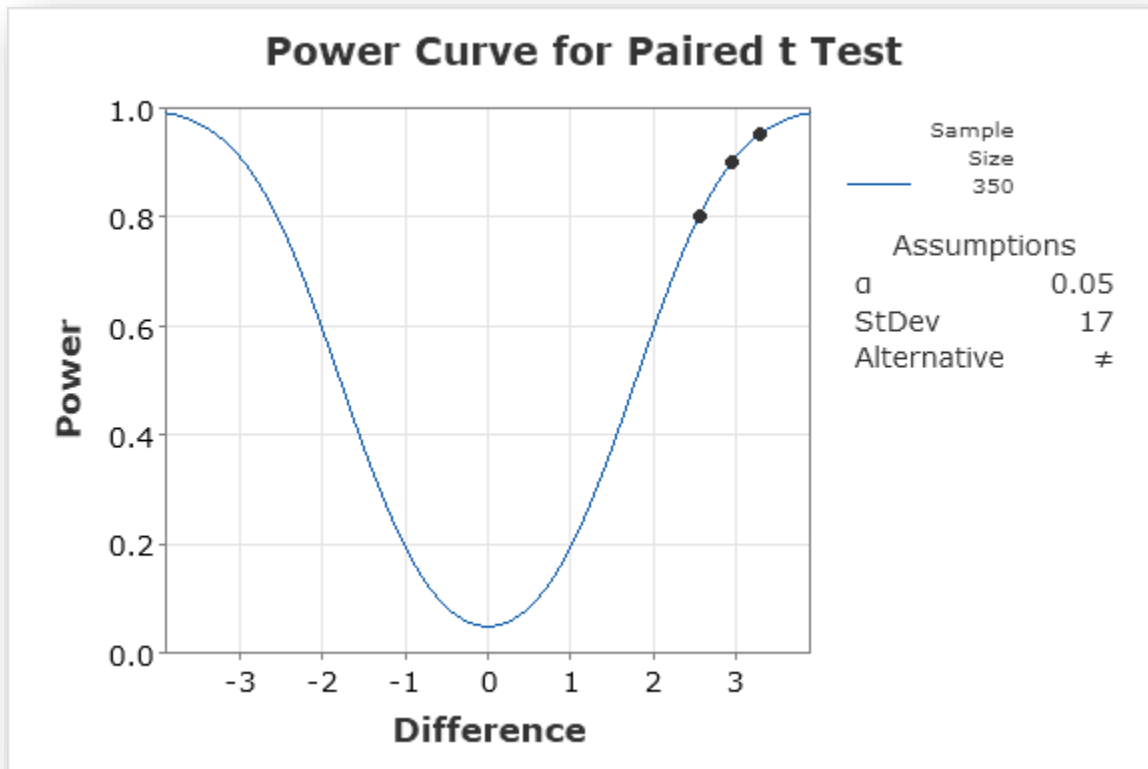
Based on a standard deviation of the scoring difference of 17 pins, a sample size of 350 bowlers will achieve 90% to detect a 3-pin difference.

Bowlers were invited to sign-up for squads throughout the week to accommodate eight bowlers bowling on two pairs of lanes. Squads were conducted every weeknight from 6 pm to 8 pm and four squads on Saturdays: 9 am, 11:30 am, 2 pm, and 4:30 pm. Hosting nine squads per week gave us the capacity to host 72 bowlers per week. Each squad bowled four games, two games on a string pin pair, and two games on a free-fall pair. The lanes were oiled with the following house shot:

FLEX

String Pin Scoring

Oil Pattern Distance	43	Reverse Brush Drop	40	Oil Per Board	Multi ul
Forward Oil Total	12.1 mL	Reverse Oil Total	14.4 mL	Volume Oil Total	26.5 mL
Tank Configuration	B Only	Tank A Conditioner	ICE	Tank B Conditioner	FIRE

	START	STOP	LOADS	MICS	SPEED	TANK	CROSSED	START	END	FEET	T.OIL
1	2L	2R	1	50	14	B	37	0.0	0.0	0.0	1850
2	9L	9R	1	50	18	B	23	0.0	2.5	2.5	1150
3	10L	10R	2	50	18	B	42	2.5	7.6	5.1	2100
4	11L	11R	3	50	18	B	57	7.6	15.2	7.6	2850
5	12L	12R	4	50	18	B	68	15.2	25.4	10.2	3400
6	13L	13R	1	50	18	B	15	25.4	27.9	2.5	750
7	2L	2R	0	50	18	B	0	27.9	38.0	10.1	0
8	2L	2R	0	50	22	B	0	38.0	43.0	5.0	0

|	START	STOP	LOADS	MICS	SPEED	TANK	CROSSED	START	END	FEET	T.OIL
1	2L	2R	0	50	30	B	0	43.0	37.0	-6.0	0
2	11L	11R	2	50	18	B	38	37.0	31.9	-5.1	1900
3	10L	10R	2	50	18	B	42	31.9	26.8	-5.1	2100
4	9L	9R	3	50	18	B	69	26.8	19.2	-7.6	3450
5	8L	8R	3	50	18	B	75	19.2	11.6	-7.6	3750
6	7L	7R	1	50	18	B	27	11.6	9.1	-2.5	1350
7	2L	2R	1	50	18	B	37	9.1	6.6	-2.5	1850
8	2L	2R	0	50	18	B	0	6.6	0.0	-6.6	0
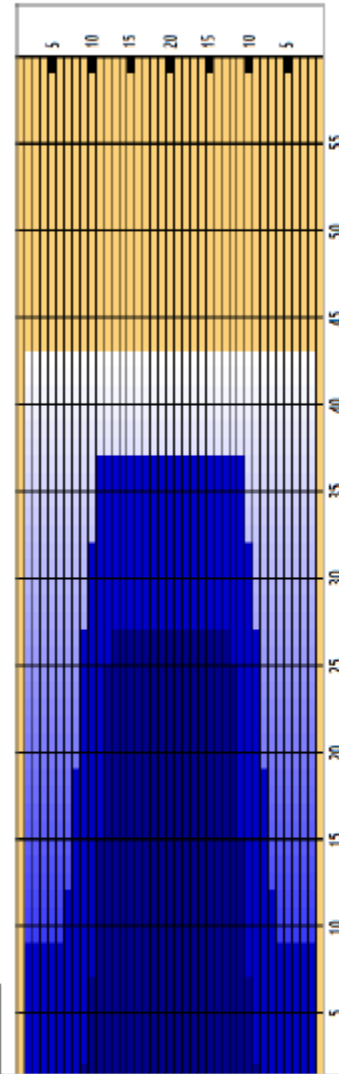
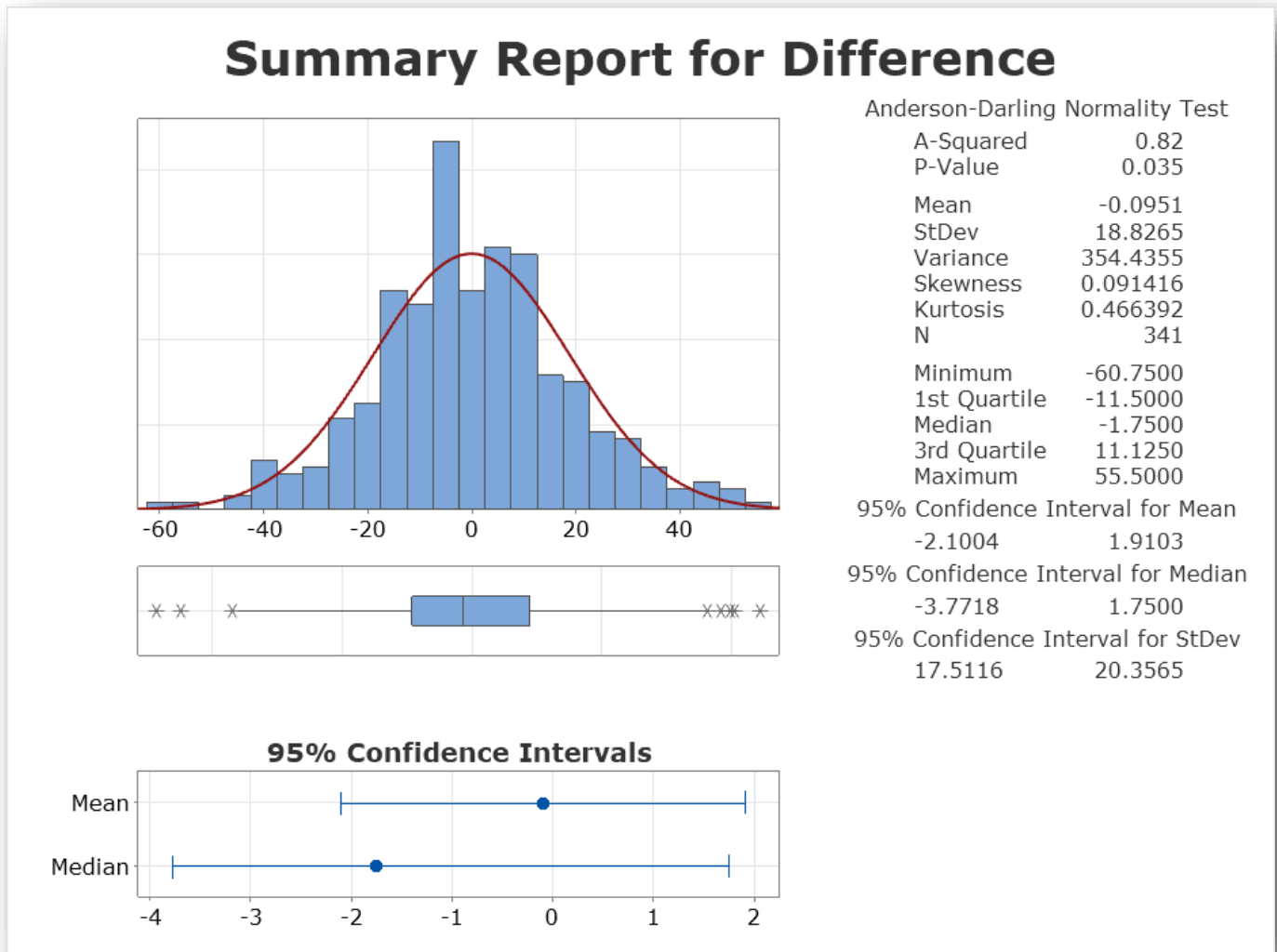|		
Cleaner Ratio Main Mix	NA	Forward
Cleaner Ratio Back End Mix	NA	Reverse
Cleaner Ratio Back End Distance	NA	Combined

Buffer RPM: 4 = 700 | 3 = 500 | 2 = 200| 1 = 100

Item	3L-7L:18L-18R	8L-12L:18L-18R	13L-17L:18L-18R	18L-18R:17R-13R	18L-18R:12R-8R	18L-18R: 7R-3R
Description	Outside:Middle	Middle:Middle	Inside:Middle	Middle: Inside	Middle:Middle	Middle:Outside
Track Zone Ratio	10.91	1.67	1	1	1.67	10.91
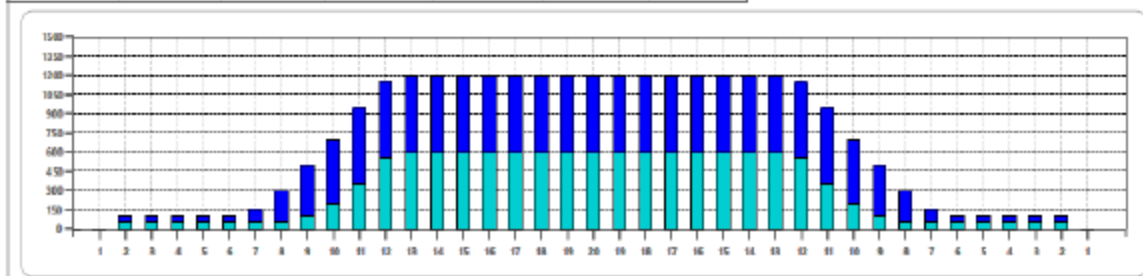
The pattern was provided to the bowlers at the time of bowling to help them understand where to play the lanes. To ensure that bowlers' ball choice did not impact the difference in scoring between the pairs, they were informed to select their best ball in practice. Once the games began, bowlers were asked to use the same ball throughout the session. Then, after completing their sessions, bowlers were asked to give anonymous comments on the process.

STRING PINSETTER SCORING RESULTS

895 sessions, 541 unique bowlers, 341 bowlers bowling more than one set, and 3550 games of bowling were conducted over the summer of 2023 to quantify scoring differences between an approved string pinsetter and traditional free-fall bowling.

Summary Report for Difference

Anderson-Darling Normality Test

A-Squared	0.82
P-Value	0.035
Mean	-0.0951
StDev	18.8265
Variance	354.4355
Skewness	0.091416
Kurtosis	0.466392
N	341
Minimum	-60.7500
1st Quartile	-11.5000
Median	-1.7500
3rd Quartile	11.1250
Maximum	55.5000

95% Confidence Interval for Mean

-2.1004   1.9103

95% Confidence Interval for Median

-3.7718   1.7500

95% Confidence Interval for StDev

17.5116   20.3565

95% Confidence Intervals

This data shows us that the trending difference in average score was 0.1 pins lower on string pinsetters. The results varied largely from one bowler to the next as we expect with scoring data, with the minimum difference scoring -60.75 pins lower on strings and the maximum difference scoring 55.50 pins higher on strings. There is not statistical difference between the scoring paces as an average difference of zero is still contained within the 95% confidence interval for the mean. The confidence interval ranges from 2.1 pins higher on free-fall to 1.9 pins higher on string pins and we would expect that the true difference in scoring between the pin setter types exists in this interval.
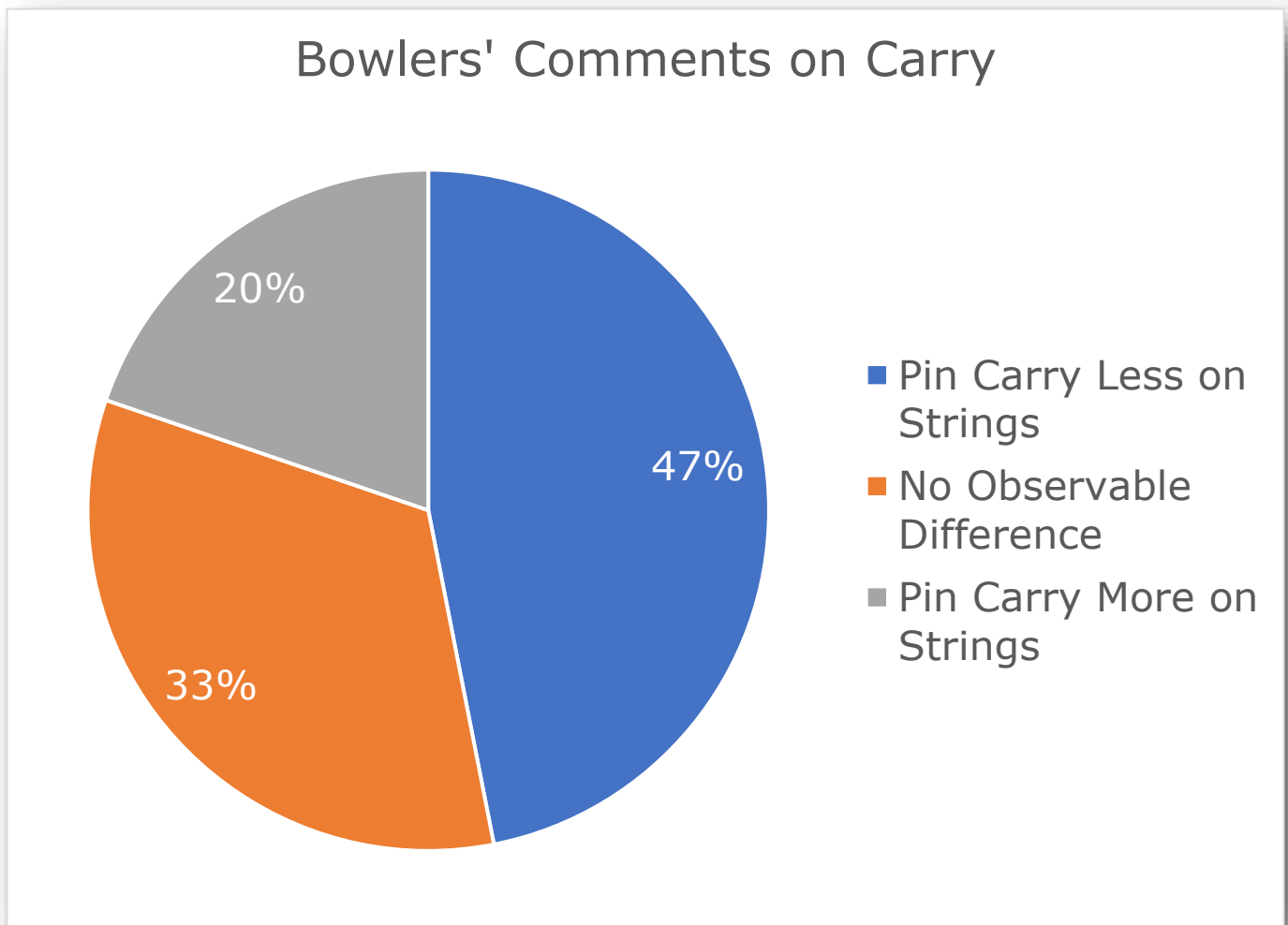
Whenever a statistical test shows no significant difference, the data must be reviewed to determine if it had enough power to detect differences. Tests gain additional power as more and more samples are gathered – or in this case as more bowlers bowl. Evaluating the power and sample size metric with the data selected shows that the test had 83.5% power to detect a 3-pin difference, 97.5% power to detect a 4-pin difference, and 99.8% power to detect a 5-pin difference. Power is the inverse of another statistic called *beta risk*. Our beta risk in this case is the probability of saying the pinsetter types score the same when they in fact do not. So, the previous powers could be rewritten to say:

- There is a 16.5% beta risk free-fall and string pinsetters may score three pins different.
- There is a 2.5% beta risk free-fall and string pinsetters may score four pins different.
- There is only a 0.2% beta risk free-fall and string pinsetters may score five pins different.
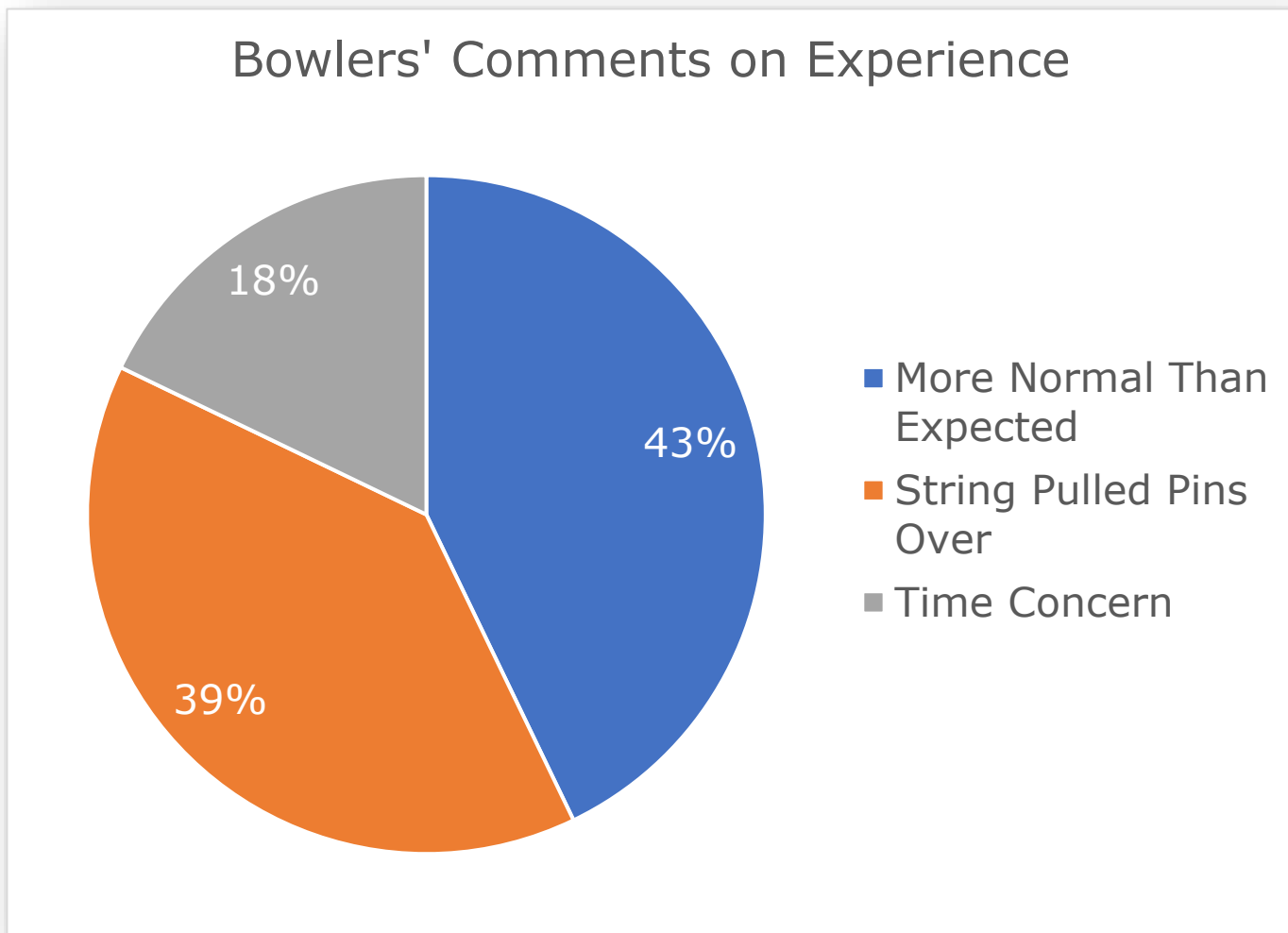
Therefore, we can say with confidence the scoring pace of the tested pinsetters is within five pins of each other.

Summary of Feedback

While the bowlers were participating, we gathered their comments on the process. Over 200 bowlers provided us with written feedback regarding their participation in the research. The feedback could be split into two main categories: feedback regarding the pin carry, and feedback regarding the overall experience.

Bowlers' Comments on Carry

- Pin Carry Less on Strings — 47%
- No Observable Difference — 33%
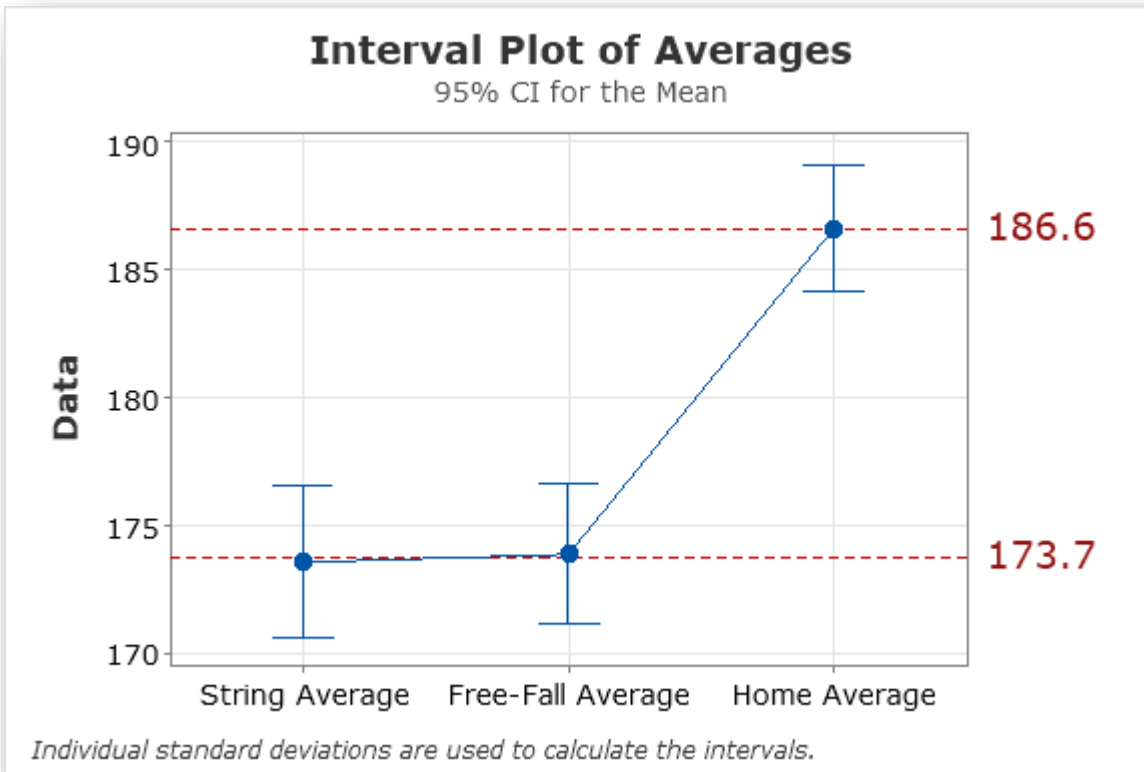- Pin Carry More on Strings — 20%

The most frequent comment on carry was that the carry was less on the string pinsetter than the free-fall pinsetter. Comments included: "left more 4 pins on strings," "strings are more dead," "no messengers on strings," "pin action is smaller and harder to strike," "less margin for error on strings," "Less pin action and carry." This aligns with the previous findings in the laboratory tests that showed a narrower strike pocket. 33% of the responses regarding carry were simply that the bowlers could not tell the difference. The minority, 20%, observed the opposite -- that string pinsetters had better carry.

Bowlers' Comments on Experience

43%

39%

18%

- More Normal Than Expected
- String Pulled Pins Over
- Time Concern

When bowlers commented on the overall experience, the most common response was that string pinsetters behaved much more normal than they had expected. Other responses included that they observed strings pulling over pins, and a handful of bowlers had concerns related to the pace of play. Of course, we know that strings are still going to pull over pins, though the new specifications developed to minimize these occurrences. While conducting the testing, with bowlers changing pairs we did not observe either the free-fall pair or the string pair completing games quicker or slower than the other.

### Scoring Results by entering average, age, and gender.

To ensure that the difference in scoring is free from bias, we asked our bowlers to provide their membership ID. We can use that information to stratify the data by any other metrics associated with them as a bowler. Here in this report, we will look at the difference in the bowlers' average between pin setter types based on their entering average, their age group, and their gender.

Interval Plot of Averages
95% CI for the Mean

*Individual standard deviations are used to calculate the intervals.*

When reviewing averages bowled in the study versus the home averages of bowlers, we find that bowlers performed approximately 13 pins lower in the study than their respective home averages. However, the difference was independent of the pin setter type bowled on at the ITRC. It makes perfect sense that bowlers would bowl a bit worse in the study due to:

- Unfamiliarity with the center and lane pattern.
- Study's limitation on ball selection.
- Limited number of games to learn and adapt.

When we view the difference in averages between free-fall and string pinsetter for the bowlers within our facility versus their entering average groups, we see no meaningful trend at this time.

Individual Value Plot of Difference
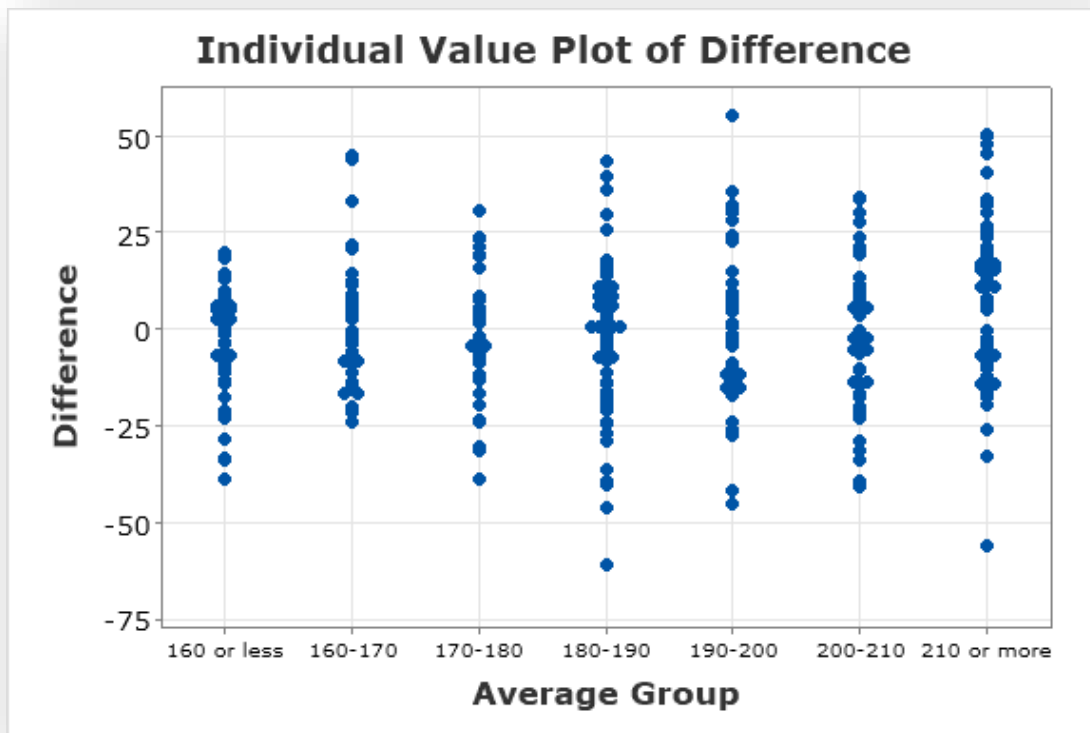
Observationally, the pin action on strings appears slower and more deadened. With observing this we want to ensure that the difference between the pinsetter types is not related to the power the shots were thrown with. One way to evaluate that is to review the scoring difference with respect to the bowlers' ages.

Individual Value Plot of Difference
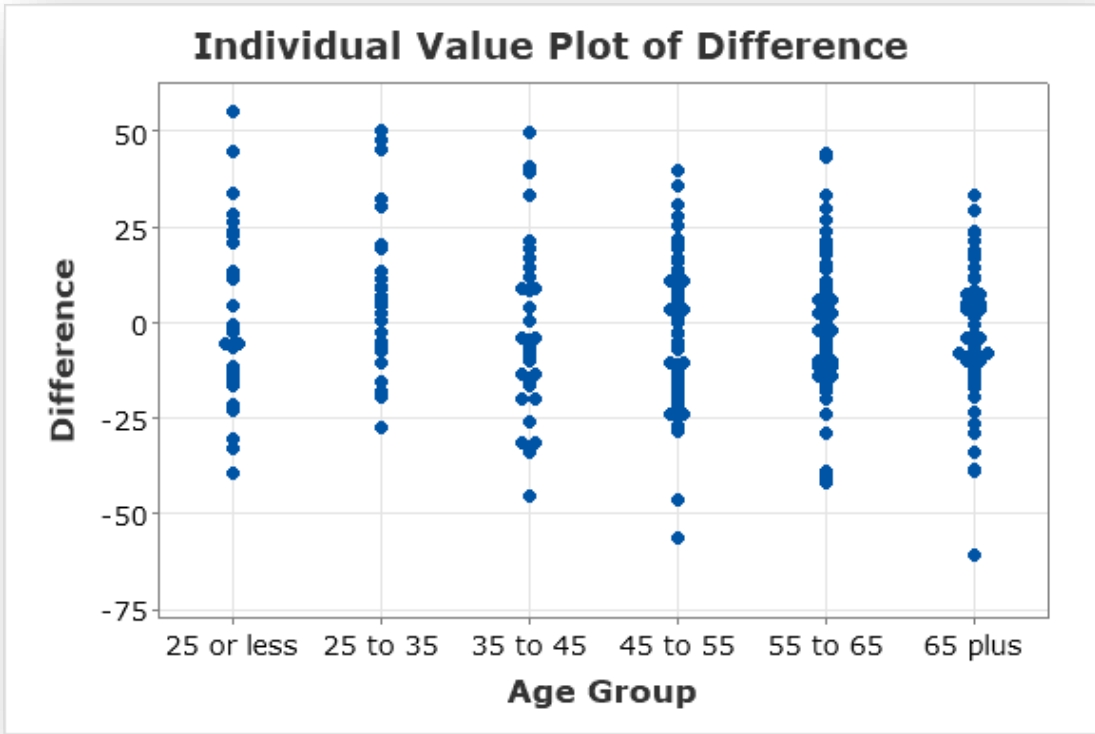
Plotting the scoring difference each bowl experienced by their age shows no correlation.

As an additional check for bias within the data, we stratified the average difference by bowler gender. The results continue to show no difference.

Means

Gender	N	Mean	StDev	95% CI
Female	62	0.59	16.74	(-4.25, 5.42)
Male	184	-0.39	20.13	(-3.19, 2.42)

Pooled StDev = 19.3348

Individual Value Plot of Difference
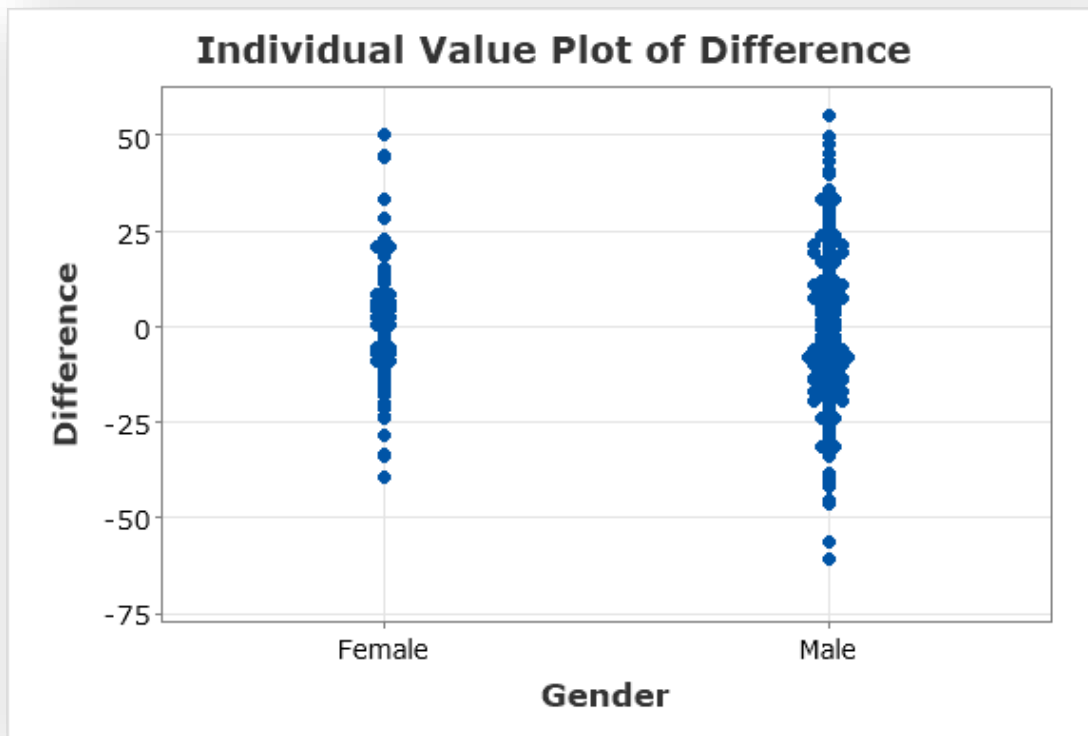
Collectively, the data is showing us that the difference in scoring pace is much, much smaller than the worst-case estimate released in our previous study. We have collected enough data to show with confidence these pinsetters score within five pins of another. The difference between these machines is well within the observed scoring differences from center to center and league to league. The bowlers' scoring differences does not show a correlation regarding average, gender or age.

Bowlscore vs. Bowlers

The question then becomes why would a laboratory-controlled experiment of a ramp rolling the ball through a rack of pins show such a stark difference in the strike percentages than what we would see with bowlers? To answer that question, let's look at the distribution of entry points into the pin deck for both studies: Bowlscore testing and the bowler testing.

Bowlscore attacks the pocket in a very standardized way. A series of 23 offsets and 11 entry angles that are all performed exactly 10 times each. That totals to 2,530 shots consisting of 23 entry points that all have exactly 110 shots at each location. That is what is known as a _uniform distribution_ and looks like this:

Summary Report for Offset
Bowlscore Entry Positions
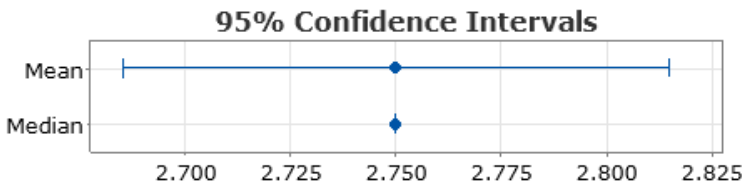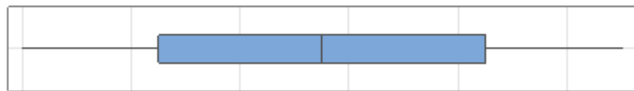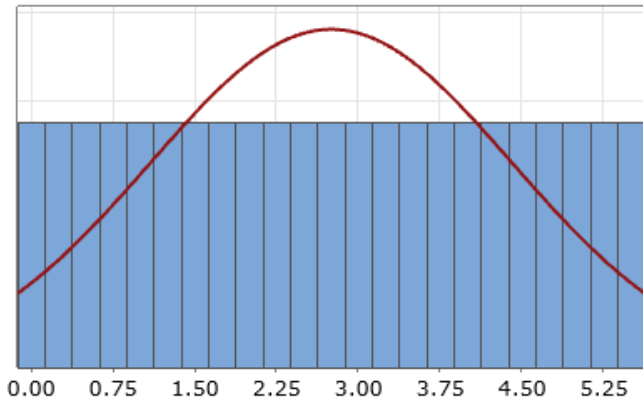
Anderson-Darling Normality Test

A-Squared	31.02
P-Value	<0.005
Mean	2.7500
StDev	1.6586
Variance	2.7511
Skewness	-0.00000
Kurtosis	-1.20455
N	2530
Minimum	0.0000
1st Quartile	1.2500
Median	2.7500
3rd Quartile	4.2500
Maximum	5.5000

95% Confidence Interval for Mean

2.6853	2.8147

95% Confidence Interval for Median

2.7500	2.7500

95% Confidence Interval for StDev

1.6142	1.7057

Notice how the data does not fill the normal bell curve, but rather has an exact shot count for each location (all the bins are the exact same height. If we convert Bowlscores offsets in inches to entry locations in boards, 0.00 offset converts to the 20 board (center of the lane and headpin). 5.5 inches offset converts to the 14.3 board, a 5.7 board range at the pins.

Now, let's contrast that with SPECTO data gathered over a night of bowling. The following is a set of 362 shots thrown at full racks of pins:
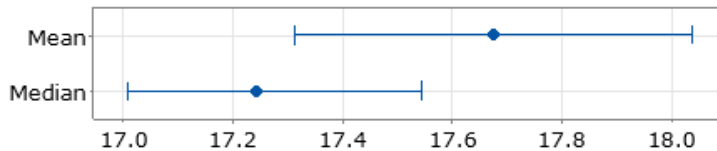
Bowling on 8-26-2023
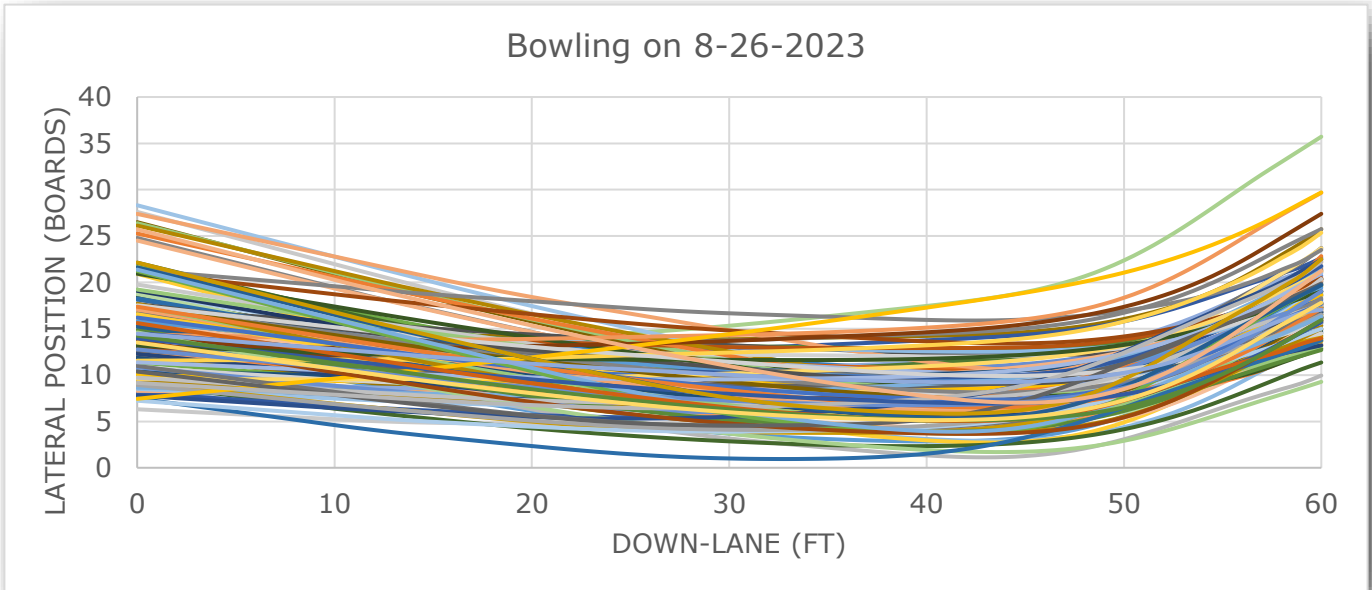
Here we see much more variation in the entry position instead of being constrained to a 5.7-board range, we see balls making it to the pins as far right as the 10 board, and as far left as the 30 board, a 20-board range. When we review the data with the same binning, we also see a very different distribution:

Summary Report
Entry Position of Bowlers
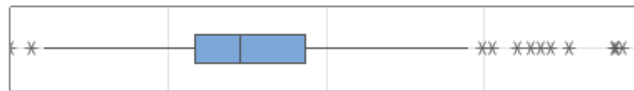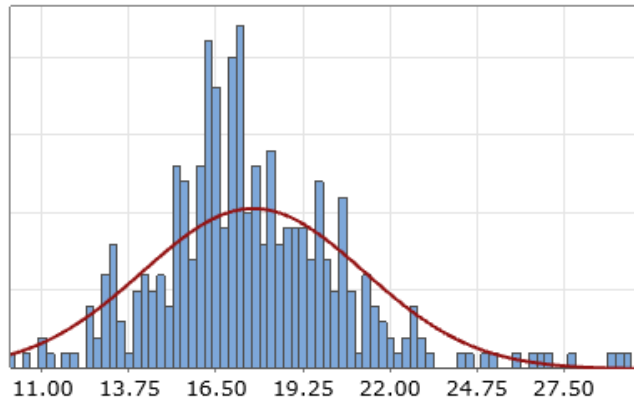
Anderson-Darling Normality Test

A-Squared	6.40
P-Value	<0.005
Mean	17.674
StDev	3.502
Variance	12.263
Skewness	2.0445
Kurtosis	11.9810
N	361
Minimum	8.919
1st Quartile	15.844
Median	17.243
3rd Quartile	19.313
Maximum	45.000

95% Confidence Interval for Mean

17.311	18.036

95% Confidence Interval for Median

17.008	17.543

95% Confidence Interval for StDev

|	
3.264	3.778

95% Confidence Intervals

This data is neither uniformly distributed or normally distributed. This data set is what we call *non-normal data*. Interesting to note the mean is the 17.6 board and the median is the 17.2 board, not surprising at all when you consider that the ideal strike position is widely considered to be the 17.5 board. Bowlers are aiming for the sweet spot, and they are pretty good at getting the ball there.

Performing a distribution identification analysis shows that a good fit for this distribution around the strike pocket is a *3-parameter loglogistic distribution*.

Histogram of EntryPosition (Full Racks)
3-Parameter Loglogistic

|	
Loc	2.758
Scale	0.1065
Thresh	1.563
N	361
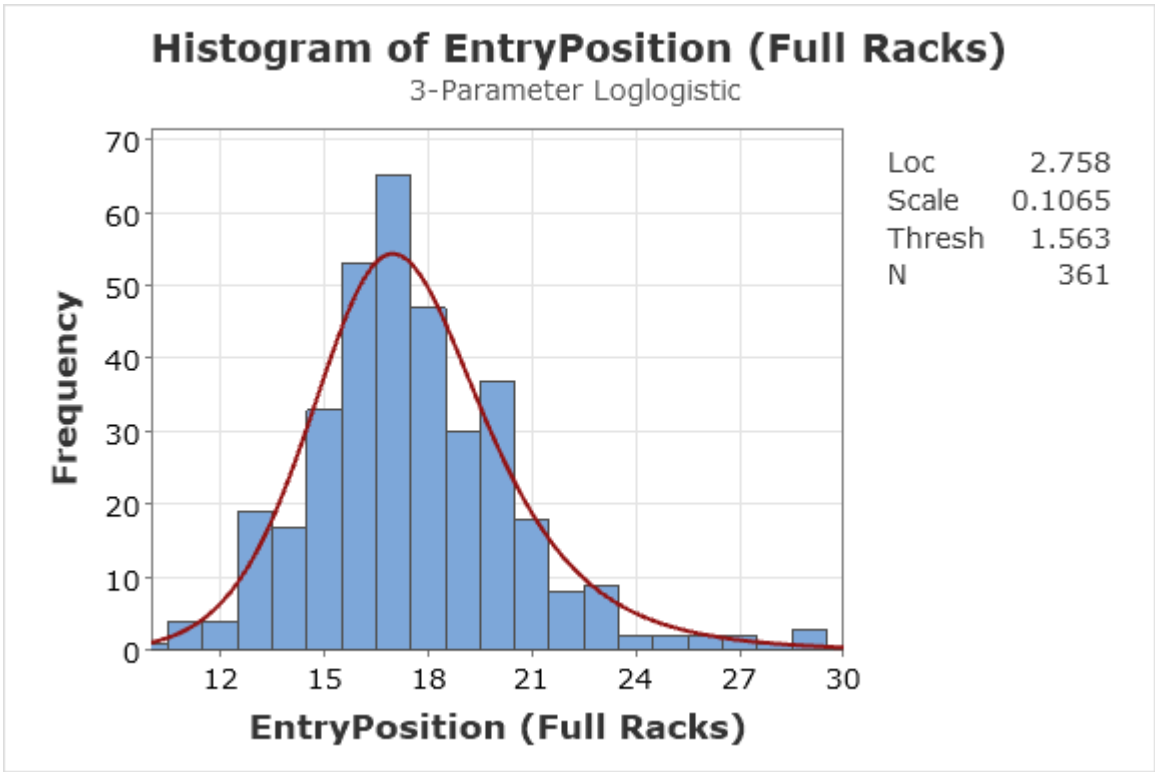
Recalling the Bowlscore results we see that the largest difference in strike percentages occurred in offsets from 0 to 1.75 inches (20 to 18.3 board) and from 4.0 to 5.5 (15.7 board to 14.3 board). These ranges contain 16 / 23 offsets (or 69.6% of the Bowlscore data).

Using the distribution analysis, we find 17.6% of bowlers' shots in the window from the 18.3 to 20 board.

Distribution Plot
Loglogistic, Loc=2.758, Scale=0.1065, Thresh=1.563

17.6%
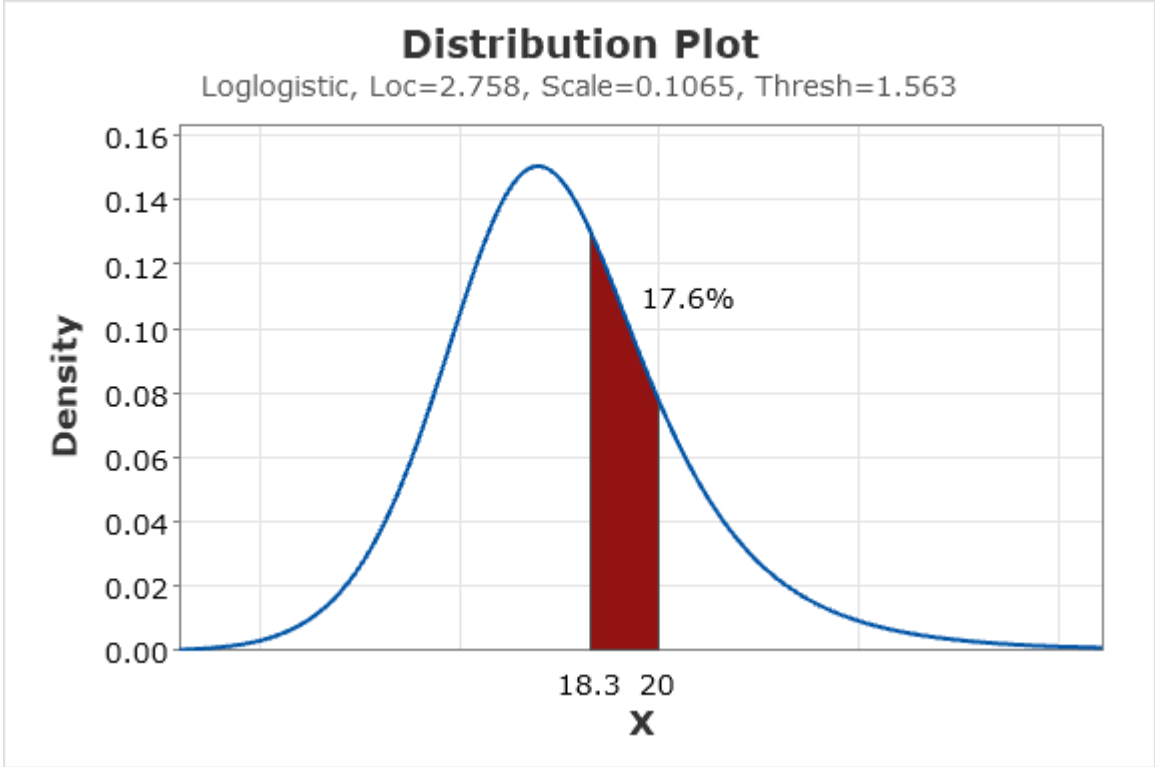
Similarly in the window from the 14.3 board to the 15.7 board we see 14.5% of the bowlers' shots.

Distribution Plot
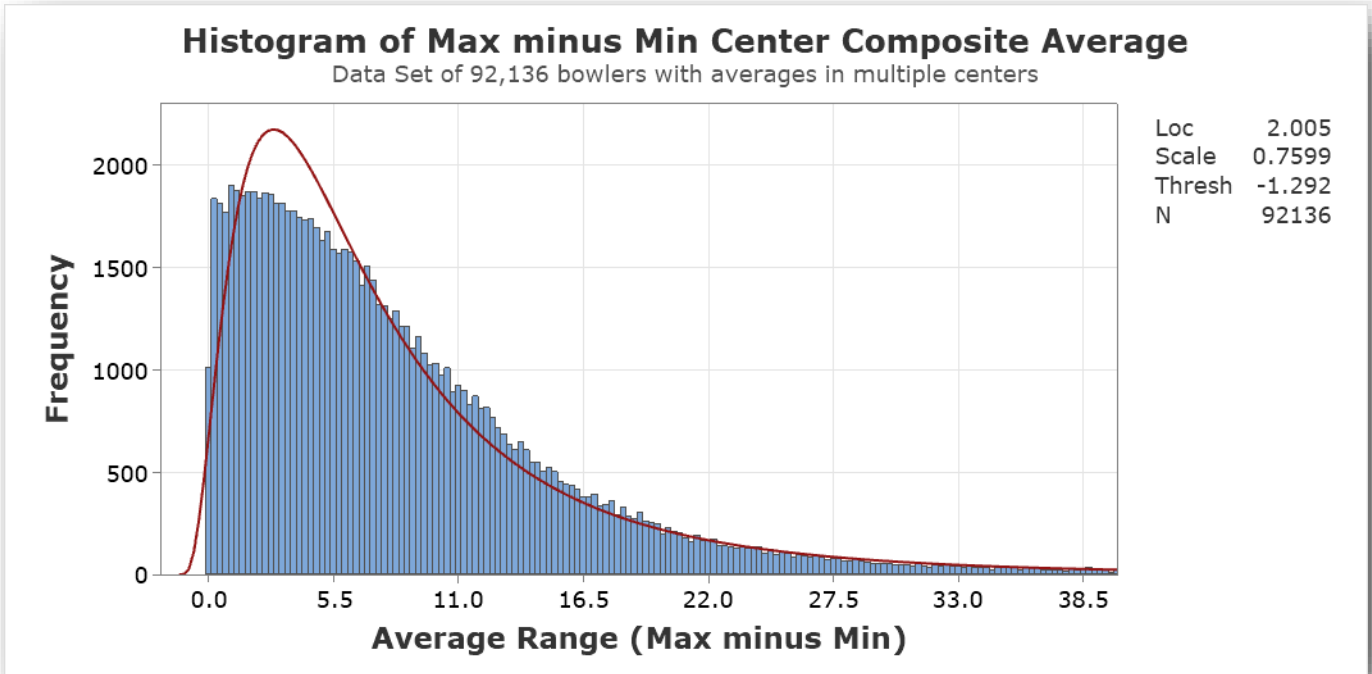Loglogistic, Loc=2.758, Scale=0.1065, Thresh=1.563
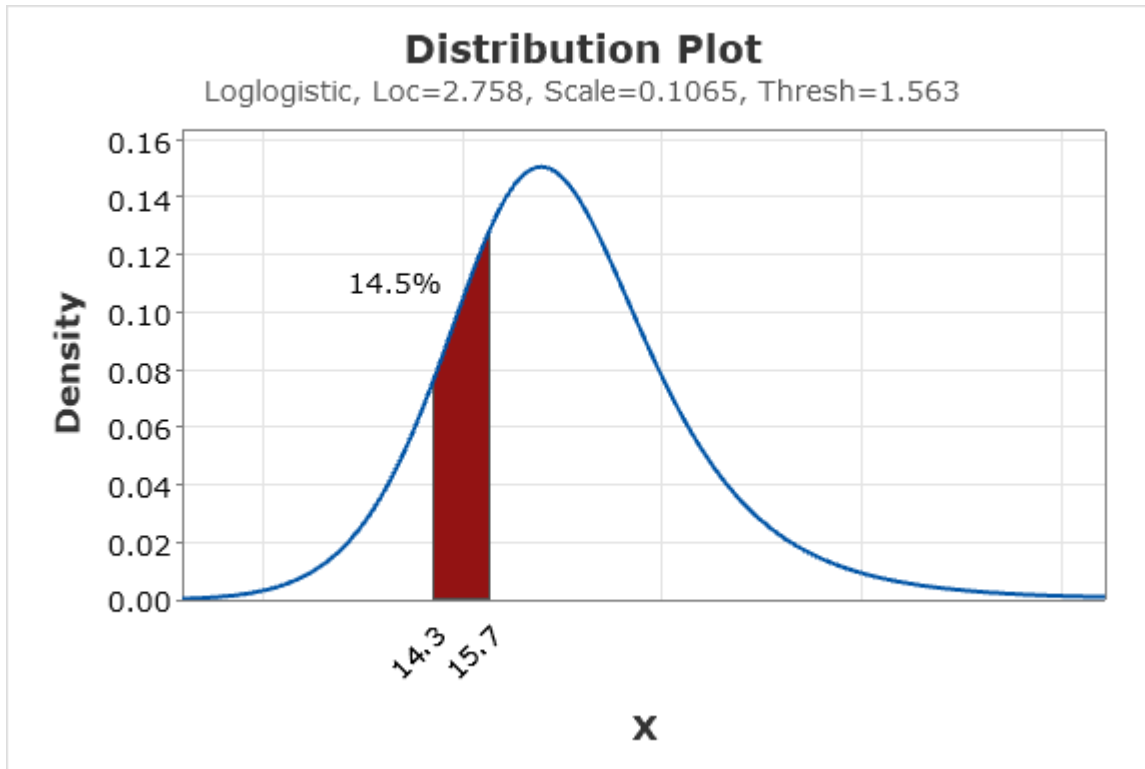
Bringing all of that together, where Bowlscore has 69.6% of its collected data in the zones where there are more strike percentage differences, bowlers only hit those locations 32.9% of the time. Additionally, we know that when balls contact the pins outside of Bowlscores offset range, they very rarely strike with the exception of some Brooklyn hits. However, when the bowlers find the true strike pocket, even Bowlscore agrees that the pins all fall down regardless of pinsetter type – just like what our bowlers experienced.

Existing Center Differences

By reviewing the bowler average data recorded from around the country, we can see the existing scoring pace differences from bowling center to bowling center. This provides added context, that in addition to our laboratory test showing no significant difference between free-fall and string pinsetter scores, center to center differences already exist and can be quantified.

Of the 937,316 members that have a certified average of at least 21 games or more in the 2022-2023 season average records, we can identify 92,136 bowlers who have averages in multiple centers. Using their total games and pins in each center they bowled allows us to calculate the maximum difference they each experienced from center to center.

Histogram of Max minus Min Center Composite Average
Data Set of 92,136 bowlers with averages in multiple centers

Loc 2.005
Scale 0.7599
Thresh -1.292
N 92136

The data best follows a 2-parameter lognormal distribution, and observed values range from as little as no difference to over 40 pins different. Following the best fit trend, we see that 29.1% of our multiple center bowlers already experience a 10 pin or more difference in their average center to center.

Distribution Plot of Average Ranges
29.1% of multi-center bowlers experience a 10 pin or larger difference

29.1%
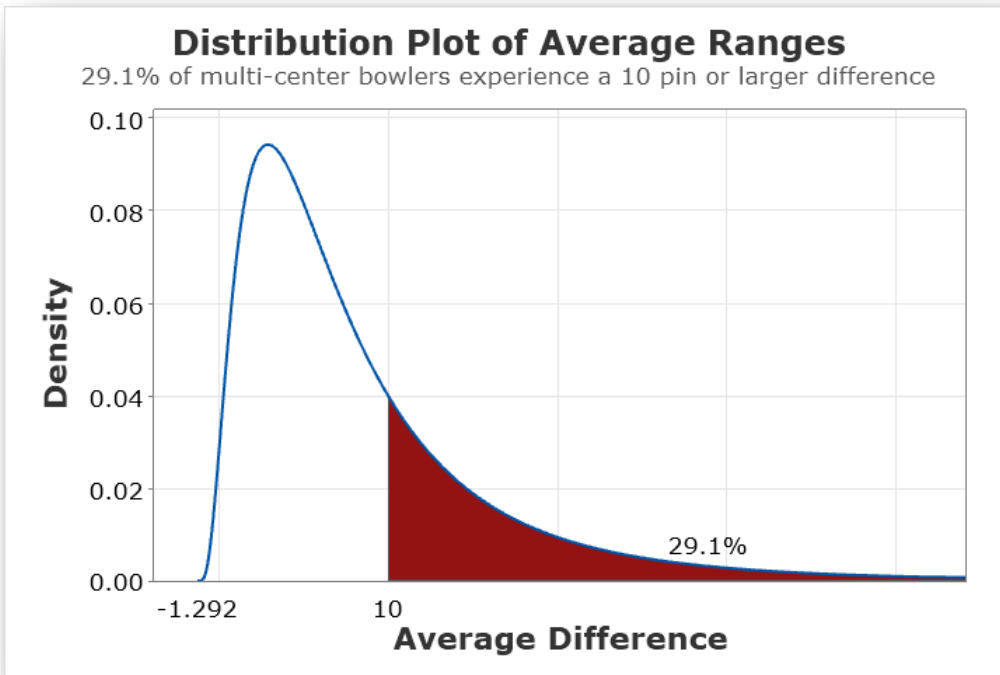
SUMMARY

The USBC Equipment Specifications has completed a four-month long study into the scoring pace between an approved string pinsetter and a free-fall pinsetter. The data shows:

- There is no statistically significant difference between the scoring pace of the pinsetter types when controlled in the same environment.
- The differences in scoring do not relate to bowlers' averages, ages or genders.
- The differences in bowler results compared to Bowlscore relate to the distribution of where the balls hit the pins.
- Based on the results of this study, an average adjustment between string pinsetter and free-fall pinsetter averages will not be needed.

Therefore, as next steps:

- Effective immediately, USBC will allow for the averages between the pinsetter types to be interchangeable.
- USBC will continue to monitor averages of bowlers around the country as some transition into string pinsetter leagues to gather additional data.