Recommendations for New Record Standards for USA Weightlifting

We present below our recommendations for USA Weightlifting Record Standards in the new bodyweight categories, for the Senior and Junior age divisions. Here we present a brief summary of how we arrived at these new standards, and in the attached Appendix there are additional technical details.

We began with the assumption that current USA records are "clean" records, set under conditions of intensive doping control. That means that there is no need to set the new standards at some level below that of the current records. When a new bodyweight category is close to an old category—for example, the new women's 76-kg category, compared to the old 75-kg category—we expect the new record standards to be very close to the current records. (There are certain exceptions to this that we discuss below.) This also means that some of the new record standards may seem relatively easy to equal and exceed, in cases when there are many lifters performing close to the current records. However, other new standards may take much longer to attain, in cases where the current records have been set far above the reach of all but a single exceptional lifter. (An example is the current Junior Men's record in the 69-kg clean and jerk.)

We have adopted two additional guidelines in creating these new standards, as follows:

1. Since there are no technical grounds for altering the records in the superheavyweight bodyweight categories, we do not recommend any changes to those records; that is, we recommend that the record standards in the +109-kg category and the +87-kg category be identical to the current records in the +105-kg and +90-kg categories, respectively.
2. With certain exceptions in the superheavyweight categories due to #1 above, we have specified the record standard in each new bodyweight category such that it is at least 1 kg *higher* than the corresponding standard in the next-lower new category.

Although some of the current records in the Junior categories are not consistent with guideline #2 above, we believe the weightlifting community would feel more comfortable if the new record standards reflect the most common feature of competitive weightlifting, that is, that weights lifted in higher bodyweight categories tend to be higher than those in lower categories. This guideline sometimes leads to new record standards that are not quite as close to current records as one might otherwise have expected. However, since we are only imposing a 1-kg minimum difference between categories, some of the new record standards in adjoining bodyweight categories are quite close to each other, and any deviation from current records will be relatively small.

In order to arrive at new standards that were as similar as possible to the current records, we looked closely at the pattern of the current records. We examined how records in each individual category compared to records in higher and lower bodyweight categories, by placing all current records in each division (e.g., Junior Women) on a single graph, plotting performance vs. bodyweight. By drawing a smooth line through the points representing current records, we were able to see where it would be reasonable to place the corresponding record in a new bodyweight category. (This line is called an "interpolation.")

On the next few pages we show tables of the current record performances, our recommendations for the new record standards, and graphs that show current records (represented by large red dots) with the recommended new record standards, represented by green diamonds.

There are several features of these graphs that should be noted:

1. The graphs do *not* show new record standards for the +87-kg or +109-kg categories, since we have recommended that the records in the superheavyweight categories remain unchanged from their current values. The following guidelines refer only to new standards, and not to the standards in the superheavyweight categories.
2. Current records are placed on the graphs at the *exact* bodyweight at which they were set; for example, the current total record of 225 kg in the 75-kg category for Junior Women was set at a bodyweight of 71.03 kg (not at 75 kg), and so on the graph it is plotted at a bodyweight of 71.03 kg.
3. As discussed on the previous page, each new record standard is specified to be at least 1 kg higher than the corresponding standard in the next-lower bodyweight category.
4. New record standards are specified to be *equal to or greater than* all current records made at lower (exact) bodyweights for the corresponding lift (snatch, clean & jerk, and total).
5. The current 90-kg records are not shown on the Senior and Junior Women's graphs, because those are themselves record standards that have never actually been achieved. Only actual performances were used to determine the pattern of current records.
6. On the graph for Senior Women, an additional performance was added as a "current record" in order to aid in determining the true relationship of performance to bodyweight. This was the performance of Marissa Klingseis at the 2016 Olympic Trials, where she snatched 112 kg, clean and jerked 145 kg, and totaled 257 kg at a bodyweight of 102.87 kg. (This performance was also used previously in the calculation of the current 90-kg record standard.) These were the highest weights ever lifted by a U.S. woman with a bodyweight under 103 kg, and so—we believe—they provide a valid and useful addition to help fill out the pattern of performance vs. bodyweight, allowing a more accurate determination of new record standards.
7. New standards were all obtained "automatically" from the points on the interpolating curve, with the exception of the Junior Men's 109-kg category. In this category, there are highly unrealistic bends in the interpolating curve caused by the anomalously low records in the superheavyweight category. For this reason, the new record standards in the Junior Men's 109-kg category were set to be 1 kg higher than the corresponding records in the 102-kg category.

   Two other small deviations from interpolating points were made in the Junior Men's category: The 55-kg record standard in the snatch was lowered from 111 kg to 110 kg, and the 81-kg record standard in the clean and jerk was lowered from 200 kg to 199 kg, to match the corresponding standards in the Senior Men's category.

Report submitted by:
David Meltzer, Chair
Dan Altman
Marianne Huebner
Les Simonton

Recommendations for New Record Standards for USA Weightlifting

Senior Men			
New Record Standards (kg)	**Total**	**Clean & Jerk**	**Snatch**
55	242	134	110
61	268	150	123
67	312	178	139
73	340	191	152
81	357	199	163
89	370	207	170
96	380	213	174
102	387	218	175
109	394	223	177
+109	*430******	*237.5******	*197.5******

**unchanged from current records*

Senior Women			
New Record Standards (kg)	**Total**	**Clean & Jerk**	**Snatch**
45	181	94	82
49	187	106	84
55	199	114	89
59	213	118	95
64	231	129	102
71	242	136	107
76	245	139	108
81	248	141	109
87	250	142	110
+87	*287******	*161******	*128******

**unchanged from current records*

Recommendations for New Record Standards for USA Weightlifting

Junior Men			
New Record Standards (kg)	**Total**	**Clean & Jerk**	**Snatch**
55	242	134	110
61	266	150	121
67	312	178	139
73	340	191	152
81	354	199	160
89	355	201	161
96	363	202	163
102	378	206	172
109	379	207	173
+109	*365****	*204****	*165.5****

**unchanged from current records*

Junior Women			
New Record Standards (kg)	**Total**	**Clean & Jerk**	**Snatch**
45	150	88	70
49	178	100	81
55	193	107	86
59	197	112	88
64	222	123	99
71	227	128	103
76	228	130	104
81	229	132	105
87	230	134	106
+87	*285****	*160****	*128****

**unchanged from current records*

Current USA Record Performances

Note: Does not include 90-kg category

Senior Men

Bwt.	Total	Bwt.	C&J	Bwt.	Snatch
55.93	245	**55.88**	136	**56.00**	112
61.81	273	**61.88**	153	**61.81**	125
68.90	324	**68.75**	185	**68.90**	144
76.42	348	**76.42**	193	**76.69**	157.5
84.14	362	**84.80**	203	**84.55**	166
93.57	377	**93.23**	211	**93.68**	173
104.81	390	**104.81**	220	**104.49**	176
158.93	430	**158.93**	237.5	**169.30**	197.5

Senior Women

Bwt.	Total	Bwt.	C&J	Bwt.	Snatch
47.85	185	**47.85**	102.5	**47.79**	83
52.86	194	**52.54**	113	**52.96**	87
57.70	208	**57.96**	116	**57.70**	93
61.87	225	**61.87**	125	**62.07**	100
68.19	239	**68.55**	134	**68.18**	106
74.65	244	**74.65**	138	**74.60**	108
102.87	257*	**102.87**	145*	**102.87**	112*
141.00	287	**141.00**	161	**129.62**	128

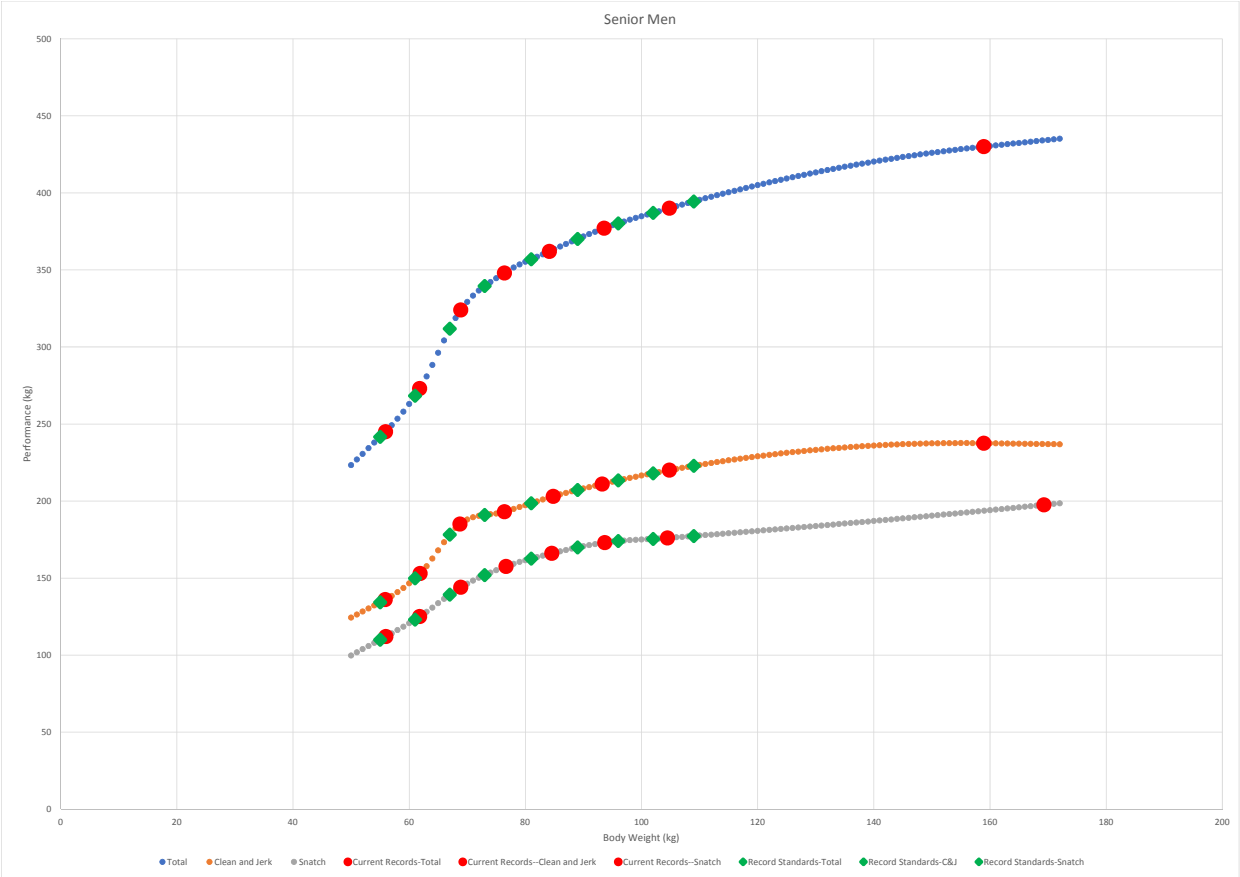
Junior Men

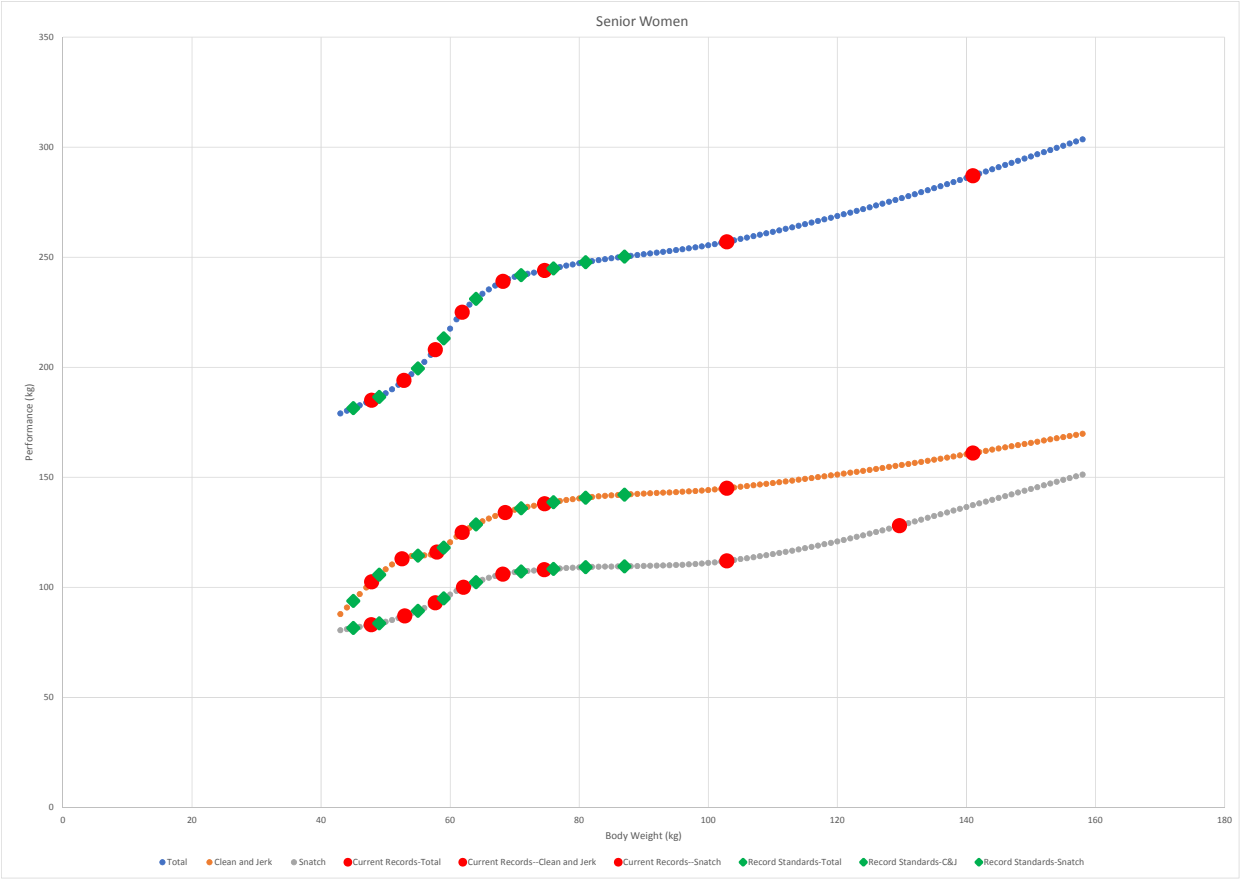
Bwt.	Total	Bwt.	C&J	Bwt.	Snatch
55.93	245	**55.35**	135	**56.00**	112
61.30	268	**61.88**	153	**61.64**	122
68.90	324	**68.75**	185	**68.90**	144
76.42	348	**76.42**	193	**76.69**	157.5
82.45	355	**81.26**	200	**82.32**	160
93.25	357	**93.25**	197	**93.25**	160
100.30	375	**100.30**	205	**102.90**	173
136.50	365	**123.94**	204	**132.04**	165.5

Junior Women

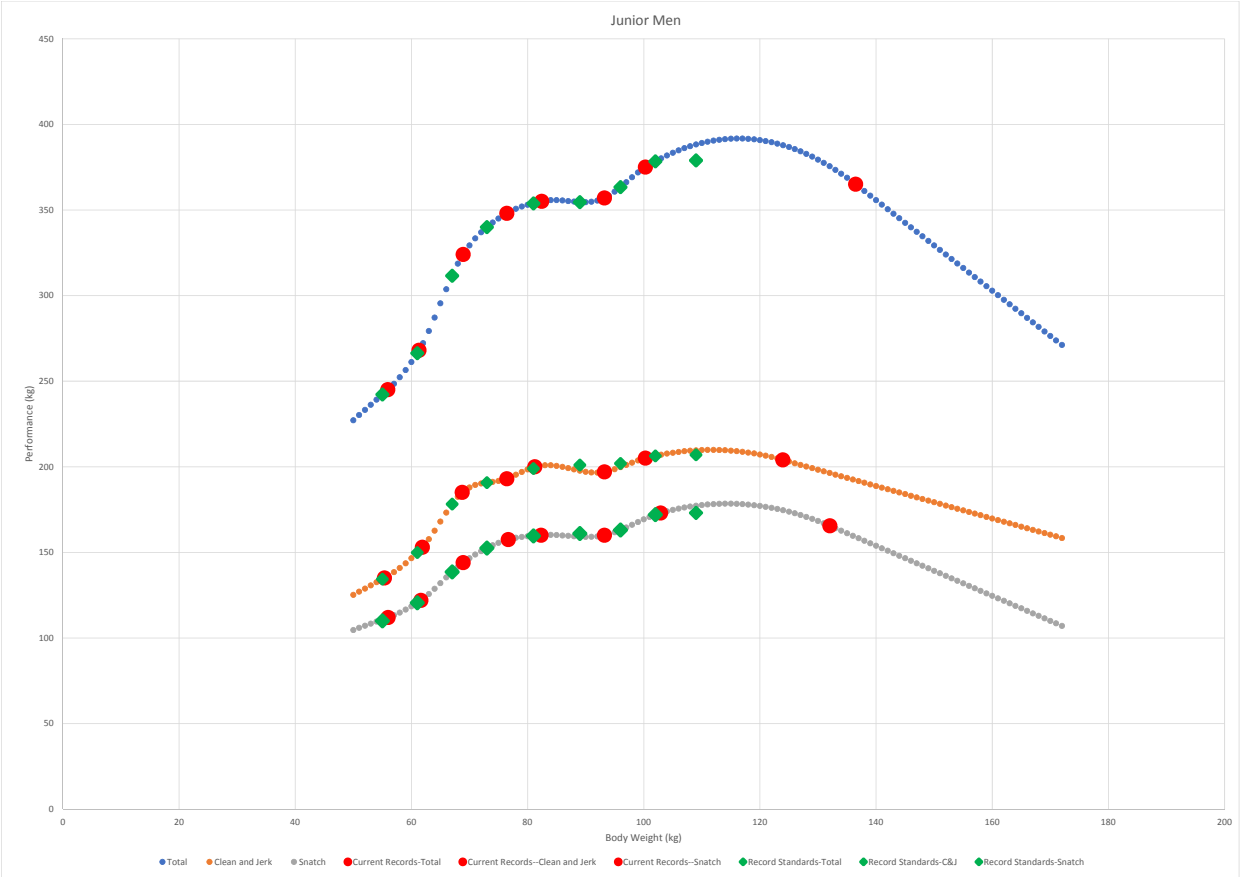
Bwt.	Total	Bwt.	C&J	Bwt.	Snatch
47.88	171	**47.88**	97	**47.94**	78
52.55	193	**52.41**	107	**52.55**	86
57.56	190	**57.21**	108	**57.56**	86
62.15	216	**63.00**	122	**62.28**	96
67.97	227	**68.29**	127	**67.97**	103
71.03	225	**71.03**	128	**72.95**	99
148.52	285	**148.52**	160	**129.62**	128

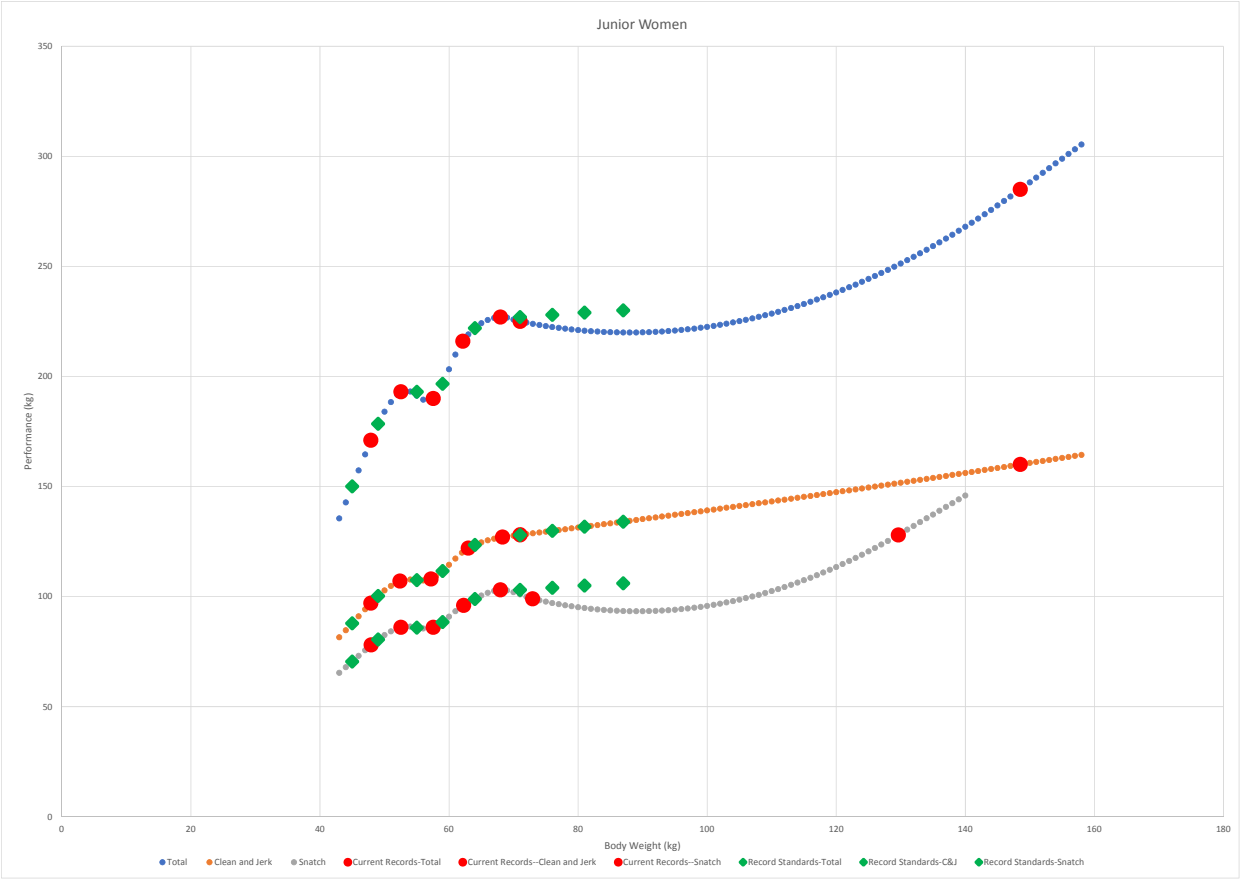
*not official record; included for statistical completeness; see text, p. 2.





Senior Men (top graph) and Senior Women (bottom graph): Current record performances (red dots), and recommended record standards in new categories (green diamonds), for total, clean and jerk, and snatch.





Junior Men (top graph) and Junior Women (bottom graph): Current record performances (red dots), and recommended record standards in new categories (green diamonds), for total, clean and jerk, and snatch.

APPENDIX

In this Appendix we discuss further technical details related to our determination of new record standards.

Summary and Overview

We approached the problem of creating new record standards from two different directions. In one, we examined various methods of interpolating and curve fitting to determine the pattern of current records, to arrive at new record standards that are highly consistent with current records; this approach is described in Sections I and II. The other approach was to examine the probability of occurrence of the various current records—for example, whether they represented a "1-in-10,000" lift or a "1-in-50,000" lift—and project those probabilities onto the new bodyweight categories, to determine new record standards with similar probability to those of the current records. This approach is described in Section III below.

Data: We used current U.S. records for each of the current bodyweight categories for Seniors and Juniors in the Olympic lifts. (However, we omitted 90-kg records for Senior and Junior Women, since those represent record standards, and not actual performances.) For each record, the name of the athlete, gender, exact body weight, location, and date was available to us; the most recent records were established July 8, 2018. In addition, we made use of the database of USA Weightlifting meet performances, focusing on national and international competitions over the period 2012-2018.

(We note that since the body weights are not normally distributed within bodyweight categories [see Figure 1], models that would depend on such an assumption are of limited use.)

Section I: Summary and Results of Curve-Fitting Approaches

Several curve fitting algorithms were applied to the U.S. record data, including linear interpolation, cubic spline interpolation, local weighted regression, and fitting to various nonlinear functions. The performances "predicted" by the various fits at the new bodyweight categories were determined and examined. It was found that the performances in the Junior Men's superheavyweight categories were anomalous, and so would require special treatment.

The various fitting and interpolation methods yielded similar results when predicting record performances at the new bodyweight categories. (Figure 2 shows results for Senior Men and Women; results are similar for the other groups.) Patterns of performances of high-caliber U.S. athletes in top international competitions also show that at different quantiles, we see curves that are similar to those found for the current U.S. records. We ultimately decided to use the cubic spline interpolation as the single basis for determining the new record standards, in that it arguably provides the closest match to the actual pattern of the current records.

The cubic spline interpolation is a composite function formed from 3rd-degree polynomials; a different function (i.e., one with different constant coefficients) is used between each pair of data points being interpolated. The functions are constrained so that their first and second derivatives

match at the data points, which ensures that the composite fitting line is continuous, smooth, and minimizes the amount of "bending" between the points. It provides us with a systematic and objective means of selecting new record standards, rather than trying to choose new standards based on dozens of individual subjective judgments for each and every new standard. It might be possible to quibble slightly with some of the specific standards yielded by the interpolation—based perhaps on "what makes best weightlifting sense"—but taken as a whole, we believe the set of new standards is very reasonable and will be broadly acceptable to the USAW community.

Figure 1: Body weight distribution of U.S. male and female athletes in international competitions

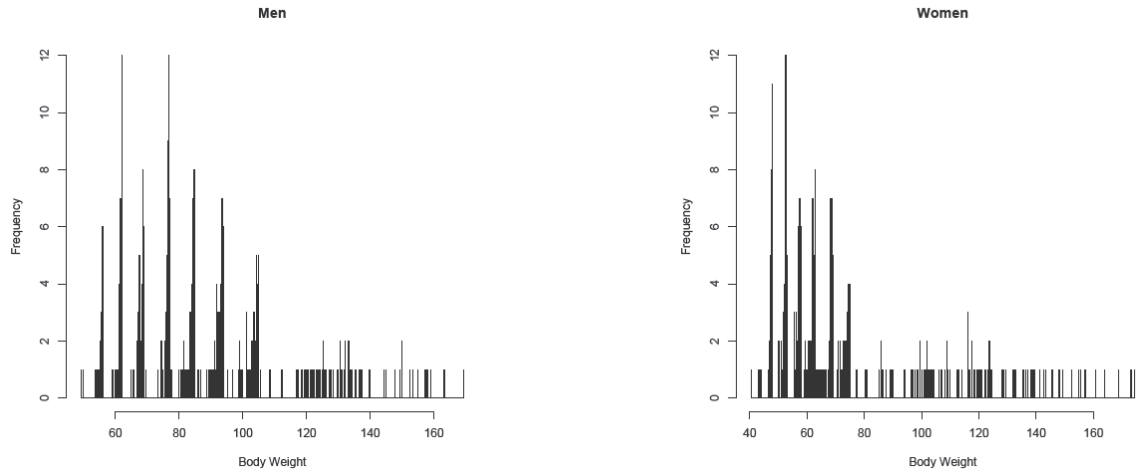
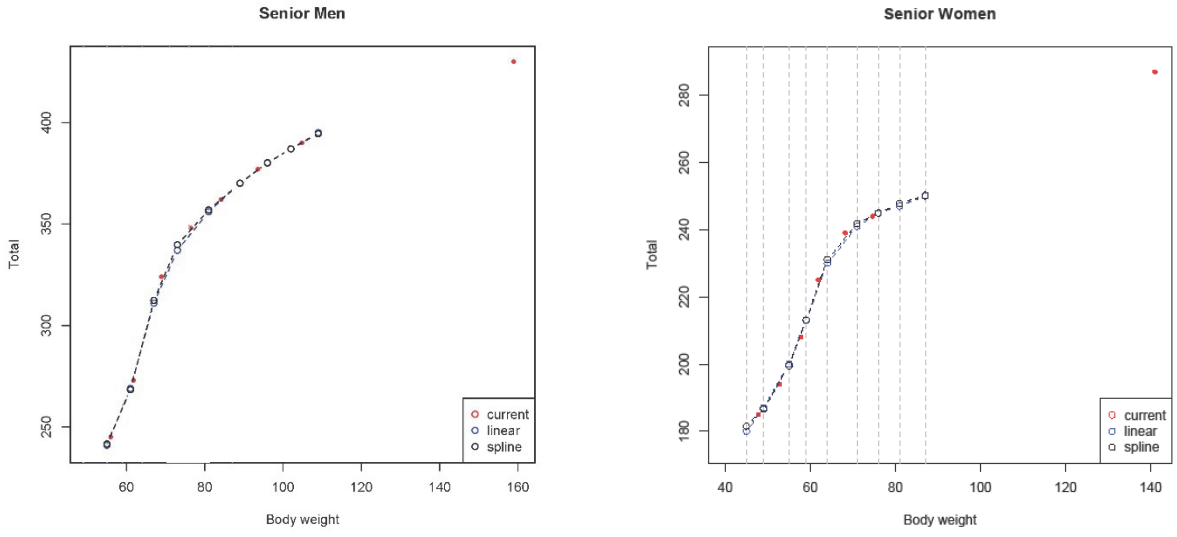


Figure 2: U.S. record spline/linear interpolation for Senior men and women.

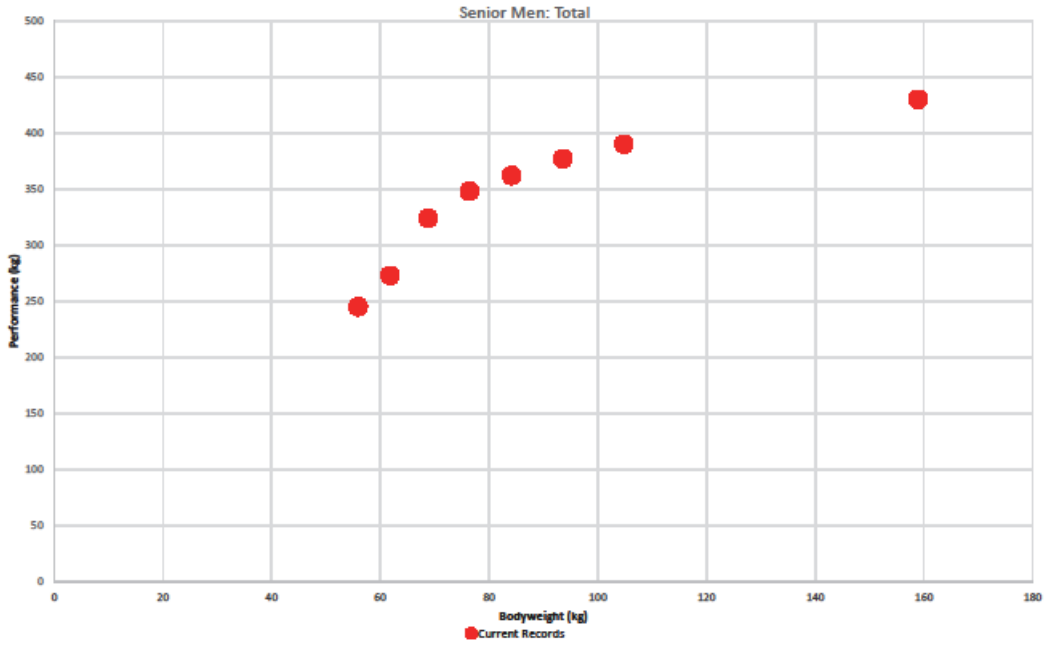


Footnote: Circles, triangles, or squares = predicted U.S. record at the new bodyweight categories with spline and linear interpolation as well as current records. On the Senior Women graph, vertical dashed lines = new body weight categories.

Section II: Discussion of Interpolation and Curve Fitting

We began this work by graphing a set of points that shows how the current American records in the different bodyweight categories are related to each other; the graph has weight lifted on the vertical axis, and lifter's bodyweight on the horizontal axis; for example, see Fig. 3; the dots in this figure represent the current men's records in the total. The question we face in creating record standards is that of determining where to place the points representing the record standards in the new bodyweight categories. We approach this problem by "fitting a curve" to the current points, and searching along that curve to find the new points. The line we draw to connect the points is called the fitting line. The fitting line may be determined through many different methods; some methods (usually called "interpolations") yield a line—not always a smooth line—that passes directly through each of the current points. Other methods make assumptions about the functional form of the curve that relates records to body weight; for example, they might assume a polynomial or exponential function. The actual records may not necessarily lie on such estimated curves, but the fit can be smooth and relatively accurate. Several such functions have been proposed in the literature; see, for example, H. Kauhanen, P. V. Komi, and K. Häkkinen. "Standardization and validation of the body weight adjustment regression equations in Olympic weightlifting." *Journal of Strength and Conditioning Research* **16** (1), 58-74 [2002]).

Figure 3: Current U.S. records for Senior Men.



It is useful to consider the implications of deriving new record standards from points interpolated or fit from a curve drawn through the current records. In some sense, it can be considered a "prediction" that if we simply wait long enough—without establishing new record standards—the new set of "best lifts" at some time in the foreseeable future would form a pattern similar to the current pattern, in that the relative ratios of the best lifts—that is, the ratios of the records in the different bodyweight categories—would be similar to what they are now. Therefore, this assumption holds that if one would draw a curve through the new future records, the curve would resemble the curve we find today. We are implicitly assuming that the ratio of the future records

in, for example, the 55-kg and 61-kg categories will be very similar to what they are now in the 56-kg and 62-kg category. (This also implicitly assumes that future maximum performances at the current bodyweights would be similar to the current record performances at those weights.) If one waited *long* enough, of course, we would expect an entirely new set of records, higher than the current ones. Here, though, we are looking toward the relatively near future.

Although these assumptions are plausible, we have not tested them in detail. Such tests might involve a systematic examination of the records at different points in the past to see whether the pattern they form—the curve drawn through those records—closely resembles the one we find today. What we do know is that the pattern we see in today's records is very similar to that found by many researchers who have examined this issue on a worldwide scale through the years. (See, for example, J. S. Croucher, "An analysis of world weightlifting records," *Research Quarterly for Exercise and Sport* **55** (3), 285-288 [1984].)

Interpolating vs. Functions

There is a difference between, on the one hand, interpolating between points representing the current records and, on the other hand fitting a function to those points with a smooth curve. A smooth functional curve may not exactly pass through the points representing the current records, and an interpolating curve (that *does* pass right through those points) may not always be very smooth. Although we gain guidance and insight from the functional curves, we have decided to base the new record standards on the spline interpolation, rather than on a smooth functional curve (such as a polynomial or exponential). The reason for this is that we believe the weightlifting community would want and expect the new record standards to be as close as possible to the current actual records, such that—for example—the record standard for the total in the new women's 71-kg category will be a little higher than the current record of 239 kg in the 69-kg category, and a little lower than the current record of 244 kg in the 75-kg category. If we were to base the new standards on a smooth fitting curve instead of an interpolation, this might not be the case; see Fig. 4 (next page) for an example. The differences are small, but they are significant.

Another choice we have made is to use a certain type of interpolation (called "spline"), because this method produces a relatively smooth curve that passes through all the points. However, in certain instances, we have made small adjustments to the results of the spline interpolation because we want to make sure that the new record standards are sensible from a weightlifting standpoint. As such, the record standard for a heavier bodyweight category should always be higher than that for a lower category—even if that may not always be the case for the nearest current records, such among the Junior women. Therefore, we always made slight adjustments to the interpolated points where necessary, in order to ensure that higher bodyweight categories always had higher records. This generally involved making increases from the interpolated points by 1 or 2 kg, occasionally more. Most of the cases in which this was done are evident from inspection of the graphs shown in the first section of this report.

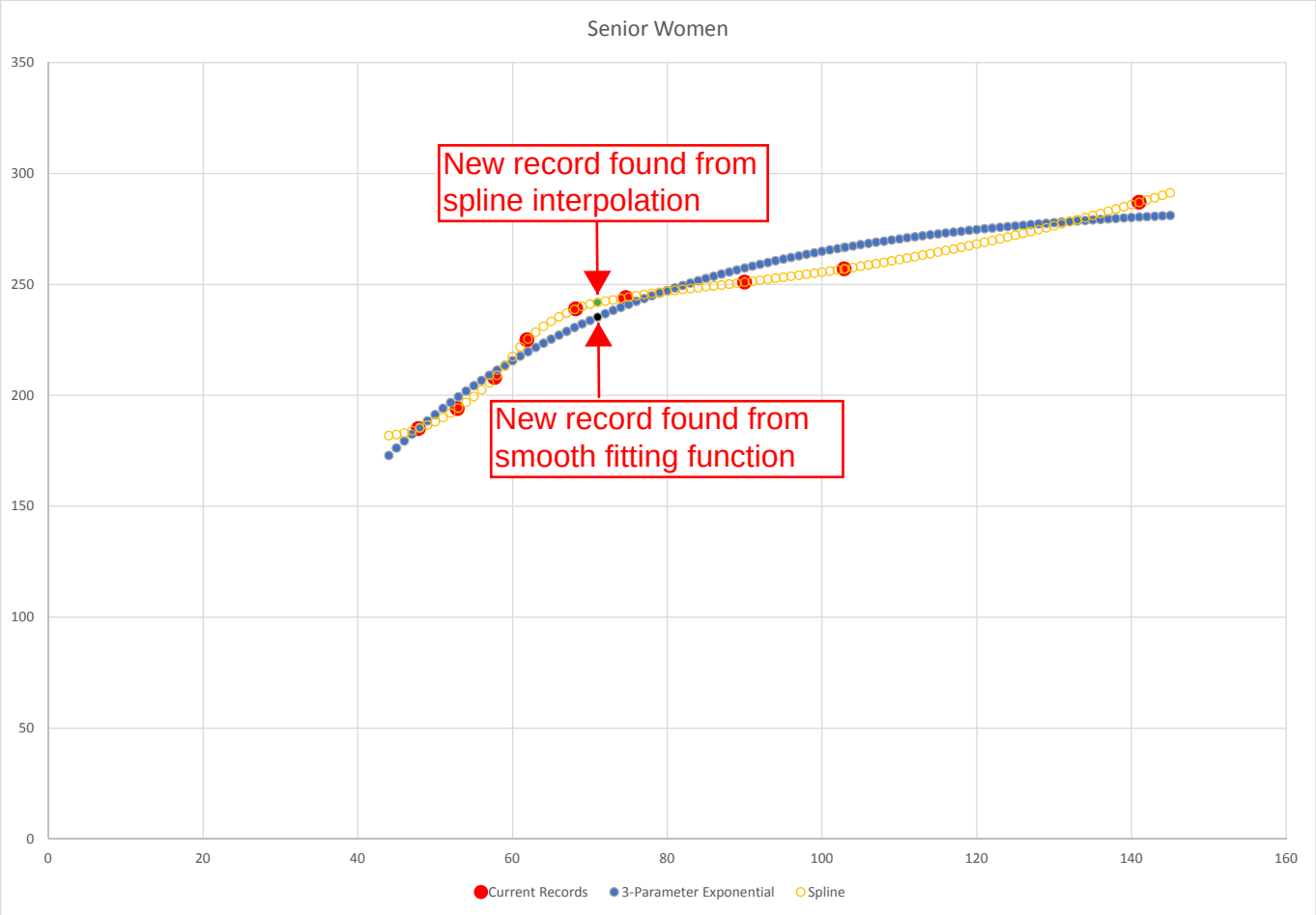


Figure 4

"3-Parameter Exponential" is a plot of the smooth fitting function $P=a-(b/c)(1-\exp(-cw))$, where P is Performance (vertical axis), w is bodyweight (horizontal axis), and a, b, and c are free parameters that represent the best fit to the data. The new record standard found from that smooth function lies below the one determined by the spline interpolation, and is less satisfactory from a weightlifting standpoint.

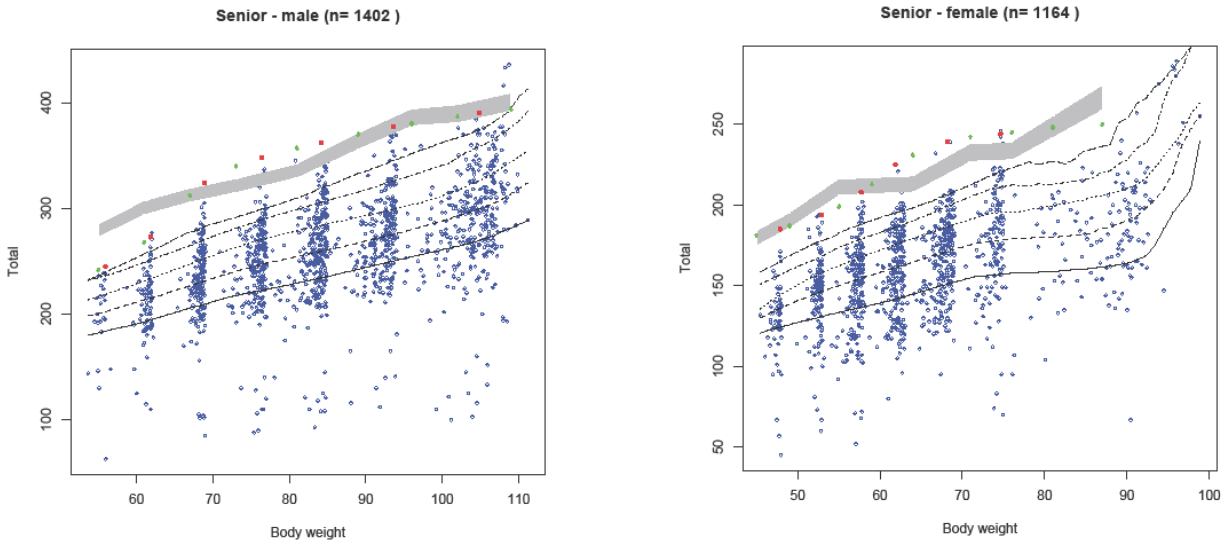
III. Likelihood of Record Performances: Different Methods

Another approach, instead of asking what pattern will be formed by comparing the *very best* lifts in each category, asks (or predicts) what pattern might be formed by comparing the *best 1%* of all lifts in each bodyweight category (or best 0.1%, or any other similar fraction). In fact, it is possible that the pattern formed by the best 1% of all lifts would be similar to the pattern formed by the very best lifts—on the other hand, those patterns might actually be different. It is possible that both of these patterns would remain similar as time goes on, or that one or both might vary.

A variation on this second approach is to ask (in effect) how rare are the current records in each bodyweight category—that is, are they a "1 in a 1000" lift, or perhaps a "1 in 10,000" lift, or something similar. We have estimated those numbers for each bodyweight category, and found that the numbers differ for different categories. However, we took a range of those probability values, and used it to determine a range for new record standards by asking what lifts would correspond to "1 in 10,000" (or the appropriate equivalent) in the new bodyweight categories, based on the pattern we observed with the old bodyweights. The implicit assumption of this method is that, as time goes on—and thousands of lifts are made in the new categories—the actual "1 in 10,000" lifts—that is, the new records—will be very similar to the 1-in-10,000 lifts we can predict now for the new categories.

The results of this approach are shown in Figure 5. For this purpose the USAW database with national and international competition results of USA athletes from 2012-2018 was used. To assess the behavior of elite lifters while still linking them to the population of lifters as a whole, a combination of the median of all lifts and the top-20 all-time lifts in each gender/category were used to determine the probabilities. The gray bands indicate the region in which we expect to find new records with approximately the same probability of occurrence as the old records. (In this figure, current records are indicated in red, and new record standards in green.) These ranges have a more "linear" pattern than the current records. As a comparison, quantile regression lines were added at 0.25, 0.5, 0.75, 0.9, 0.95 quantiles; these lines pass through the performances we expect that would be better than 25%, 50%, 75%, etc., of all future performances at any given body weight. These regression lines also appear more linear than the current records.

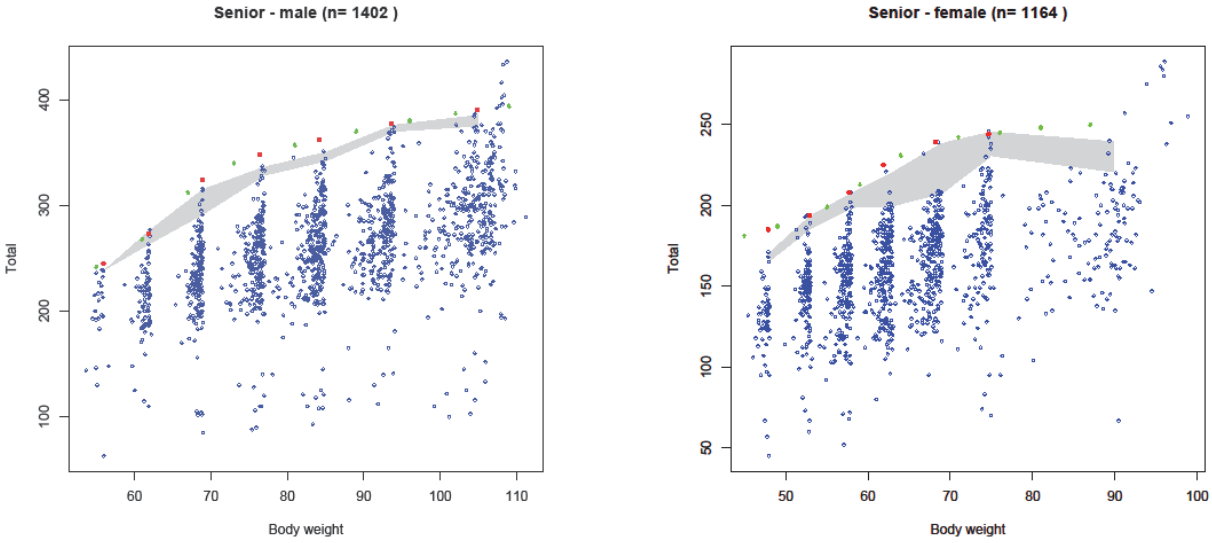
Figure 5: Region (gray bar) of likely occurrence of records in new bodyweight categories.



We see that some of the current records and proposed record standards lie well above the gray area, while others lie within or below it. This may indicate that record performances follow a different pattern than other high-level performances. It may also suggest that some of the proposed record standards might not be achieved by the current population of lifters in the immediate or near future.

Alternative approach: Another variation is to examine the top competition results at current body weight categories and, from those, estimate a confidence interval for the top lift—the record—at the new bodyweights. This is analogous to estimating a range of performances that would be expected to include each record. (The method we used for this is called "calculation of bootstrap confidence intervals.") Results drawn from the top 10% of competition results are shown in Fig. 7. Data include most national and international competitions during 2012-2018, counting only one best lift per year per athlete, for USA athletes only.

Figure 7. Range of performances (gray band) expected to include new records at any bodyweight.



The gray band in this figure represents, with 99% confidence level, the range of performances expected to include the record at any given bodyweight. (This means that if we were to examine 100 randomly drawn samples of top performances, 99 of them would be expected to have a top performance that's included within the gray band.) Where the gray band is narrow, many lifters are close to the top performance, and so there is less variation for maximum performance. Where the band is wide, there may be only one or two exceptional lifters, and so we are much less certain that other lifters can achieve this level at this time. We see that the gray band follows the trend of both actual records, and our proposed record standards, fairly closely.

IV. Final Summary and Conclusion

We acknowledge the uncertainties in achieving the new standards. However, we have concluded that the weightlifting community would be more comfortable with new standards that are close to the current records, even if they do indeed represent events that might not be achieved with equal probability in the foreseeable future.