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Original Article

Comparison of springboard diving scores between high school and club competitions: scoring analysis and correction method

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Abstract
Problem Statement: In the United States, collegiate diving coaches look at two main types of competitions to recruit divers: state high school leagues and club leagues such as USA Diving or the Amateur Athletic Union. It is generally perceived that the judging between these two types of competition is not consistent, but few studies have been conducted to quantify these potential inconsistencies and analyze whether these are individual or systemic biases. **Purpose:** By comparing equivalent dives from the same diver in both a high school and club diving meet, this study sought to identify judging differences and develop a method for correcting scores between high school and club competitions. **Approach:** Using all applicable scores across a five-year timespan (2016-2021), including factors such as gender and type of dive, investigators analyzed one-meter springboard diving scores to ascertain if scoring discrepancies exist between club and high school diving competitions. **Results:** The results revealed statistically significant differences between club and high school net scores for each dive type (all $p<0.001$), and medium-to-large effect sizes were found for all sub-groups, ranging from 0.577-0.753, except for female reverse dives, which displayed large ES of 0.808. Subsequently, researchers identified correction values to more accurately compare scores between high school and club competitions. **Conclusions:** Statistical analysis demonstrates significant differences in scoring between club and high school diving scores for all dives and sub-groupings of dives and divers, thus warranting a method for remediating these differences. The corrections developed may provide an initial step towards objectifying scoring within a subjectively scored sport, as well as improving collegiate diving recruitment.
Keywords: diving; sport; correction; performance; recruitment; subjective sports

Introduction

Competitive diving presents an intriguing opportunity to apply statistical analysis to competitive outcomes within a subjectively judged sport. Similarly scored sports such as ice skating and gymnastics utilize many of the same scoring formats and elements. However, in most cases, the judges' scores are based upon several elements joined together within a larger program. In competitive diving, each dive receives specific scores which are aggregated into a final score. As each dive is individually scored, this provides substantially more data points for analysis, and allows for a more granular evaluation of the factors that contribute to competitive success.

Statistical analysis of competitive diving has existed for decades (Bruno 1986; McGee 2019). However, in all cases, competition data has been limited to individual competitions or analysis of a small subset of divers throughout a season. A review of similar, subjectively judged sports reveals similar limitations (Ansorge & Scheer 1987; Bučar et al., 2012; Leandro et al., 2017). The advent and adoption of computer systems and online diving meet management programs have allowed for the creation of databases which house hundreds of thousands of diving scores. Among the largest of these programs, *divemeets.com* boasts over 650,000 diving sheets and over 20 million judges' scores (*https://secure.meetcontrol.com/divemeets/system/index.php*). These databases include many data points for each dive performed, allowing for a wide array of potential analyses. Yet, returning to the subjective nature of competitive diving scoring, it is vital to first consider if all diving scores and all diving competitions are equal. Prior to executing deeper analyses into diving scoring, one must first evaluate if scores provide adequate comparisons across various diving leagues; if they do not, then scores must be remediated to achieve meaningful analysis.

In the United States, there are multiple types of diving competitions. These include summer league/country club, high school, club/age group, college, and masters. Summer league and country club competitions tend to be more recreational and have limited duration training and competitive seasons. On the other hand, high school meets are interscholastic competitions where divers compete with their high school against other high schools, typically within their state. Club or age group competitions are analogous to 'travel

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teams' or private training groups that compete individually and as teams. As in high school competitions, within collegiate competitions divers compete with their college or university against other colleges and universities. Masters competitions have age minimums and age restrictions within their competitions; these meets are limited to adults aged 18 or 21 and over. While many divers compete solely in one type of competition, it is also common for divers to compete across different types of competitions. In sports where objective metrics determine place finish, such as track and field, swimming, and basketball (2022 Division I Men's Swimming and Diving Qualification Standards, NCAA Altitude Conversion Software 1.2, Cabarkapa et al., 2022) competitions across different organizations can easily be translated. A sprinter, swimmer, or basketball player competing on a similar track, pool, or a court should post a similar score/time/outcome regardless of the competitive organization. However, the subjective nature of diving scoring presents investigators with added complexity as it cannot be assumed that scores in one type of competition are representative of scores in another type of competition.

Utilizing data from five years of diving competitions, the purpose of the present study was to determine if a statistically significant difference exists between diving scoring at club and high school meets. If indeed there are systemic scoring differences between types of diving competitions, any subsequent statistical analyses seeking to utilize this, or similar competition data sets should be equalized. Fédéracion Internationale de Natacion (FINA) is the international governing body for competitive diving. FINA judging standards are the international standard, and require judging training and certification. While not all club judges are FINA-certified, there is a substantially larger preponderance of FINA certified judges in club meets. Also, FINA judges are utilized for USA and many other countries' national championships. Furthermore, FINA certified judges are required for international competitions. USA and other nations' national championships are typically the qualifying events for international competitions. As such, it was determined that club competitions should serve as the baseline for evaluating and equalizing all other diving competitions. In consultation with several elite diving coaches, it was hypothesized that:

1. A statistically significant scoring difference exists between high school and club competition types; the investigators sought to determine if that was true, the magnitude of any potential discrepancies, and if these discrepancies apply to all dive directions.
2. If these discrepancies exist, an effective method can be derived for correcting discrepancies between club and high school diving scores.

Methods

Publicly available data obtained from Dive Meets website (*divemeets.com*) over a five-year span (i.e., 2016-17 through 2020-21 season) was examined in the present study. Only data from divers that performed the same dive, in the same position, at the same height (i.e., one-meter springboard for all dives in this study), at least once in both a high school and club competition within the same school year was included in the analysis procedures. As each state's high school athletics governing body sets its own sports calendar, schoolyear (e.g., 2016-17) was selected as the competitive timeframe instead of a calendar year. The schoolyear time period was defined as September 1st to August 31st. In instances where an individual performed the same type of dive multiple times, the results were averaged. The total number of dives examined in the present investigation is 20,476.

Diving scores are assessed on a 0–10-point scale at ½ point increments. Individual diving competitions may have two, three, five, or seven judges. When there are two judges, each score is multiplied by 1.5 and summed to achieve a net score. For three judges all three scores are summed to achieve a net score. For five judges the highest and lowest scores are removed, and the remaining three scores are summed. For seven judges the two highest and two lowest scores are removed, and the remaining three scores are summed. Ultimately, the net score is multiplied by the *degree of difficulty*, a fixed value respective to each individual dive, ranging from 1.2 to 3.2. For club competitions, *degree of difficulty* is determined based upon a formula established and updated on a quadrennial basis by FINA. In general, high school competitions default to the FINA formula. However, there are some differences, determined by rule changes within high schools' governing body (i.e., National Federation of State High School Associations). Due to the aforementioned discrepancies, this study focused on examining Net scores.

Descriptive statistics, means and standard deviations ($\bar{x}\pm SD$), were calculated for each dependent variable. Shapiro-Wilk test corroborated that the assumption of normality was not violated. Dependent t-tests were used to examine statistically significant differences between club and high school net scores, separately for each dive type (i.e., forward, backward, reverse, inward, twisting) and gender (i.e., female, male). Cohen's *d* was used to calculate the measure of effect size (ES; i.e., d=0.2 small effect, d=0.5 moderate effect, and d=0.8 large effect; Cohen, 1988) and intraclass correlation coefficient (ICC) to determine the internal consistency of the measurements. Linear regression and Bland-Altman plots were used to examine strength and graphically display the relationship between club and high school net scores. Statistical significance was set *a priori* to $p<0.05$. All statistical analyses were completed with SPSS (Version 28.0; IBM Corp., Armonk, NY, USA) and all figures were completed with RStudio (Version 2022.07.02 Build 576; PBC, Boston, MA, USA).

Following the initial statistical analysis, to offer a practical solution for the discrepancy between club and high school net scores, a correction factor was determined. First, all club net scores for each sub-group (e.g., female forward, male backward) were averaged. Second, the obtained scores were divided by the respective mean value of sub-group high school net scores. Lastly, all high school net scores were multiplied by their respective correction factor to re-examine the efficacy of this approach.

Results

Descriptive statistics, means and standard deviations, are presented in Table 1. Statistically significant differences were found between club and high school net scores for each dive type (all $p<0.001$). Medium-to-large ES were found for all sub-groups, ranging from 0.577-0.753, except for female reverse dives, which displayed large ES of 0.808. ICC demonstrated moderate levels of agreement for all sub-groups, ranging from 0.511-0.682.

Graphical representation of the agreement between the club and high school net scores are presented in Figure 1-2. Moreover, correction coefficients and descriptive statistics for the corrected data set for each sub-group are presented in Tables 2 and 3, respectively.

Table 1. Club and high school net diving scores respective to gender and diving type.

Female						
n	Dive Direction	Club Net Score	HS Net Score	p-value	ES	ICC
1454	Forward	16.19 ± 2.91	18.03 ± 3.42	<0.001	0.579	0.682
1310	Backward	16.26 ± 2.80	18.33 ± 3.47	<0.001	0.657	0.648
1194	Reverse	15.73 ± 2.94	18.39 ± 3.57	<0.001	0.813	0.556
1351	Inward	17.19 ± 2.70	19.45 ± 3.26	<0.001	0.755	0.658
1215	Twisting	15.45 ± 2.74	17.55 ± 3.29	<0.001	0.694	0.603
Male						
n	Dive Direction	Club Net Score	HS Net Score	p-value	ES	ICC
787	Forward	16.86 ± 3.03	18.85 ± 3.83	<0.001	0.576	0.703
708	Backward	16.32 ± 2.90	18.40 ± 3.77	<0.001	0.618	0.643
672	Reverse	15.61 ± 3.10	18.07 ± 4.10	<0.001	0.677	0.631
789	Inward	17.52 ± 2.74	19.83 ± 3.65	<0.001	0.716	0.685
758	Twisting	16.14 ± 3.11	18.63 ± 3.78	<0.001	0.719	0.703
Note: n=number of dives; HS=high school; ICC=intraclass correlation coefficient; ES=effect size.						

Table 2. Regression equations for each sub-group.

Dive Direction	Female	Male
Forward	Y = 0.521x + 6.793	Y = 0.514x + 7.164
Backward	Y = 0.480x + 7.467	Y = 0.449x + 8.065
Reverse	Y = 0.428x + 7.862	Y = 0.445x + 7.564
Inward	Y = 0.530x + 6.887	Y = 0.512x + 7.368
Twisting	Y = 0.453x + 7.489	Y = 0.570x + 5.475

Table 3. Descriptive statistics for the actual club and corrected high school net diving scores respective of gender and diving type.

Female						
n	Dive Direction	Club Net Score	Corrected HS Net Score	p-value	ES	ICC
1454	Forward	16.19 ± 2.91	16.20 ± 3.09	0.839	0.003	0.759
1310	Backward	16.26 ± 2.80	16.26 ± 3.07	0.975	0.000	0.743
1194	Reverse	15.73 ± 2.94	15.73 ± 3.04	0.972	0.000	0.683
1351	Inward	17.19 ± 2.70	17.19 ± 2.88	0.941	0.000	0.779
1215	Twisting	15.45 ± 2.74	15.45 ± 2.90	0.992	0.000	0.701
Male						
n	Dive Direction	Club Net Score	Corrected HS Net Score	p-value	ES	ICC
787	Forward	16.86 ± 3.03	16.87 ± 3.42	0.953	0.003	0.784
708	Backward	16.32 ± 2.90	16.31 ± 3.35	0.922	0.003	0.732
672	Reverse	15.61 ± 3.10	15.63 ± 3.54	0.894	0.006	0.738
789	Inward	17.52 ± 2.74	17.53 ± 3.23	0.918	0.003	0.803
758	Twisting	16.14 ± 3.11	16.15 ± 3.27	0.896	0.003	0.818

Discussion

Currently, a limited amount of research has been done directed towards objectively analyzing diving scoring. Some studies reviewing biases within judges have been conducted (Osório, 2020). Yet, even among those few studies, the research largely investigates international competition, with multiple studies finding a nationalist bias within specific judges (Emerson et al., 2009). Others have found a difficulty bias, with judges giving lower scores to dives with high degree of difficulty (Bruno 1986). The aforementioned studies, which all focus on the results of a single competition, provide context to a subjective score, but are limited to one set of diving judges. This study proposes that judging discrepancies between two types of competitions are not centered upon individual judges, but rather represent systemic differences. Additionally, while analysis of, and recognition of bias is important, previous studies fail to provide a method of mitigating these issues.

While dive scoring is inherently subjective, quantitative weighting based on equivalent dives from the same person allows for the closest thing to objective scoring possible. Weighting is a common tactic used to compare scores in sports with more objective metrics. In swimming, the National Collegiate Athletic Association (NCAA) establishes official weights used to convert times between short-course yard, short-course meter, and long-course meter pools (*https://www.ncaa.org*).

The conversion also subtracts specific amounts of time for competitions in high altitudes. A recent study has established weights to convert times between the different types of facilities in track (Barnes & Malcata, 2017). Some sports, specifically baseball, have created objective statistics to measure subjective attributes to their game. In Major League Baseball, *park factor* quantifies the purported difficulty of each stadium based upon a plethora of game-related statistics (*https://www.mlb.com*).

The systemic scoring differences identified in this study between club net scores and high school net scores will not be a surprise to many diving coaches. However, heretofore these differences have not been proven or quantified. As such, it has been impossible to make a calculated attempt to remedy these systemic scoring differences. This data analysis, as evidenced in Table 1, proves that there is a significant systemic difference between club and high school net scores.

Demonstrably, there is a difference, one that must be corrected if one seeks to make more adequate comparisons within diving scores. This is a first step towards making diving scores more objective, allowing for accurate comparisons of scores. Previously, to compare athletes, each coach or individual can only develop their own arbitrary corrections through personal experience and estimation. Regression equations, are provided on Table 3. This correction method is simple to implement, and it can easily provide coaches and other individuals a method for more accurate analysis of diving scores across diving leagues. The authors acknowledge that more complex statistical methods could provide increased accuracy; however, the primary intended utility of this information is to provide divers and diving coaches with easy-to-use information in a practical setting that can guide training, competition, and recruiting. Absent the information this study provides, diving scores present a skewed representation of divers' actual performance levels.

Conclusion

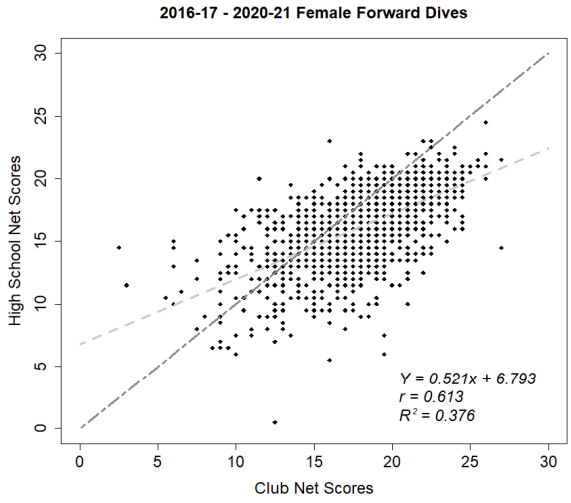
In conclusion, with quantitative corrections or weights in place, selective processes such as college recruitment can be enhanced via this much more accurate representation of a diver's true quality. Quantitative recruitment processes are common occurrences in other sports. Beginning with Bill James' 1985 Baseball Abstract, recruiters in baseball have developed many projection methods for players entering Major League Baseball (MLB) (James, 1985). James established a series of calculations which can predict player's quality in the MLB from their play in others league, including the minor leagues, foreign competitions, and the Negro Leagues (Johnson, 2020).

This method has expanded, with subsequent studies conducting more in-depth analysis of minor league prospects, with the ability to look at specific factors within a player's game (Johnson, 2006). With the correction proposed in the present study, this process has been achieved in diving. While previous scores are not the only factor in collegiate diving recruitment, this weighting system can bring needed objectivity to an immensely subjective process. Further research is warranted to refine the corrections. Additionally, future research will test differences in scoring between and within levels of intercollegiate competition and between collegiate competition and club competition. In totality, this information will provide a framework for making accurate evaluations of divers across competitive diving leagues, allowing for more nuanced, objective analyses of competitive diving.

Acknowledgements

Thank you to Andy Flower, Julie Heckman, and Right Triangle Consulting, without whom this project would not have been possible. Their time, insight, and expertise have been invaluable. Thank you as well to Dr. Lisa Wolf-Wendel for her assistance with statistical aspects of this project.

Figures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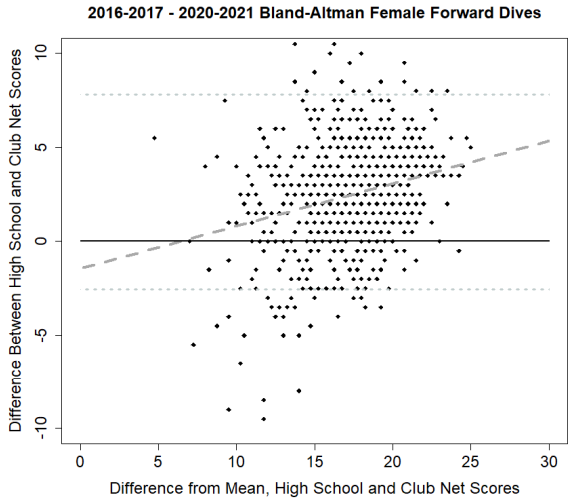
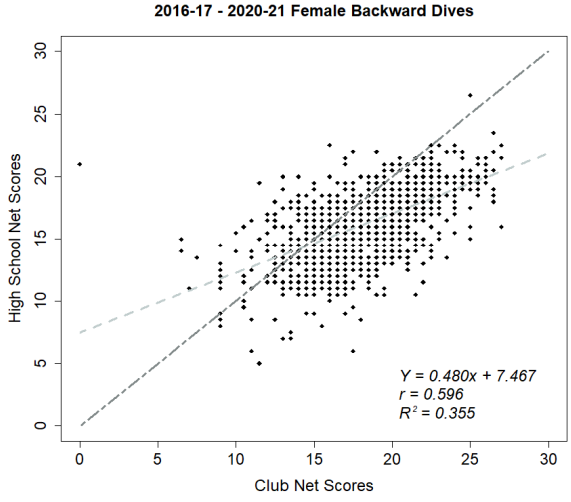
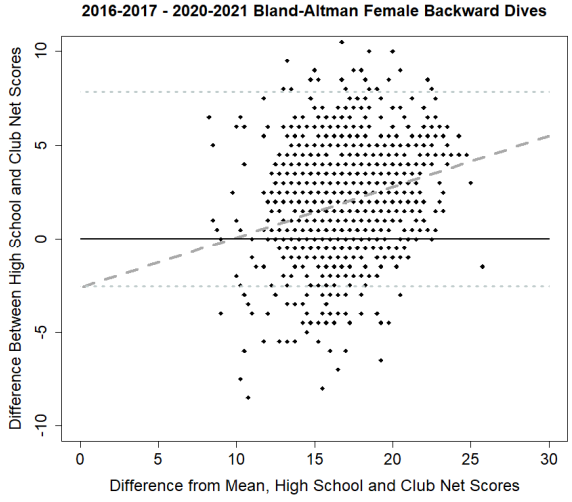
High School Net Scores
Club Net Scores
Y = 0.521x + 6.793
r = 0.613
R² = 0.376


2016-2017 - 2020-2021 Bland-Altman Female Forward Dives
Difference Between High School and Club Net Scores
Difference from Mean, High School and Club Net Scores


2016-17 - 2020-21 Female Backward Dives
High School Net Scores
Club Net Scores
Y = 0.480x + 7.467
r = 0.596
R² = 0.355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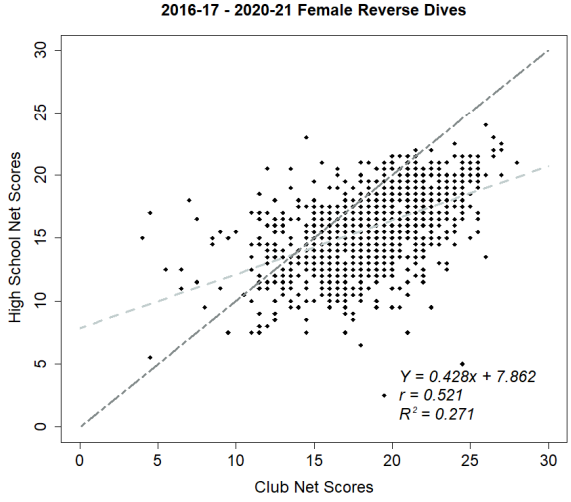
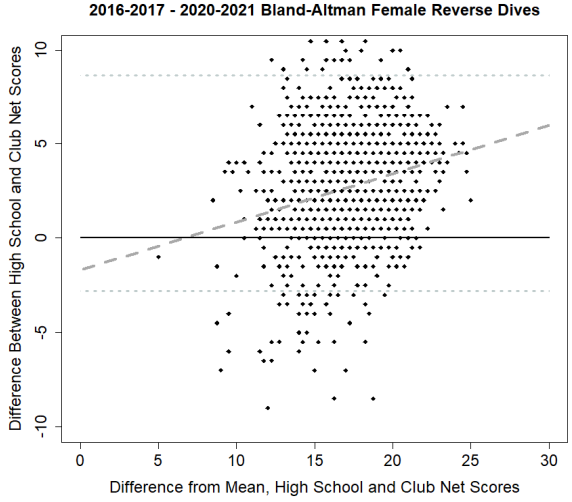
Difference Between High School and Club Net Scores
Difference from Mean, High School and Club Net Scores


2016-17 - 2020-21 Female Reverse Dives
High School Net Scores
Club Net Scores
Y = 0.428x + 7.862
r = 0.521
R² = 0.271


2016-2017 - 2020-2021 Bland-Altman Female Reverse Dives
Difference Between High School and Club Net Scores
Difference from Mean, High School and Club Net Scores

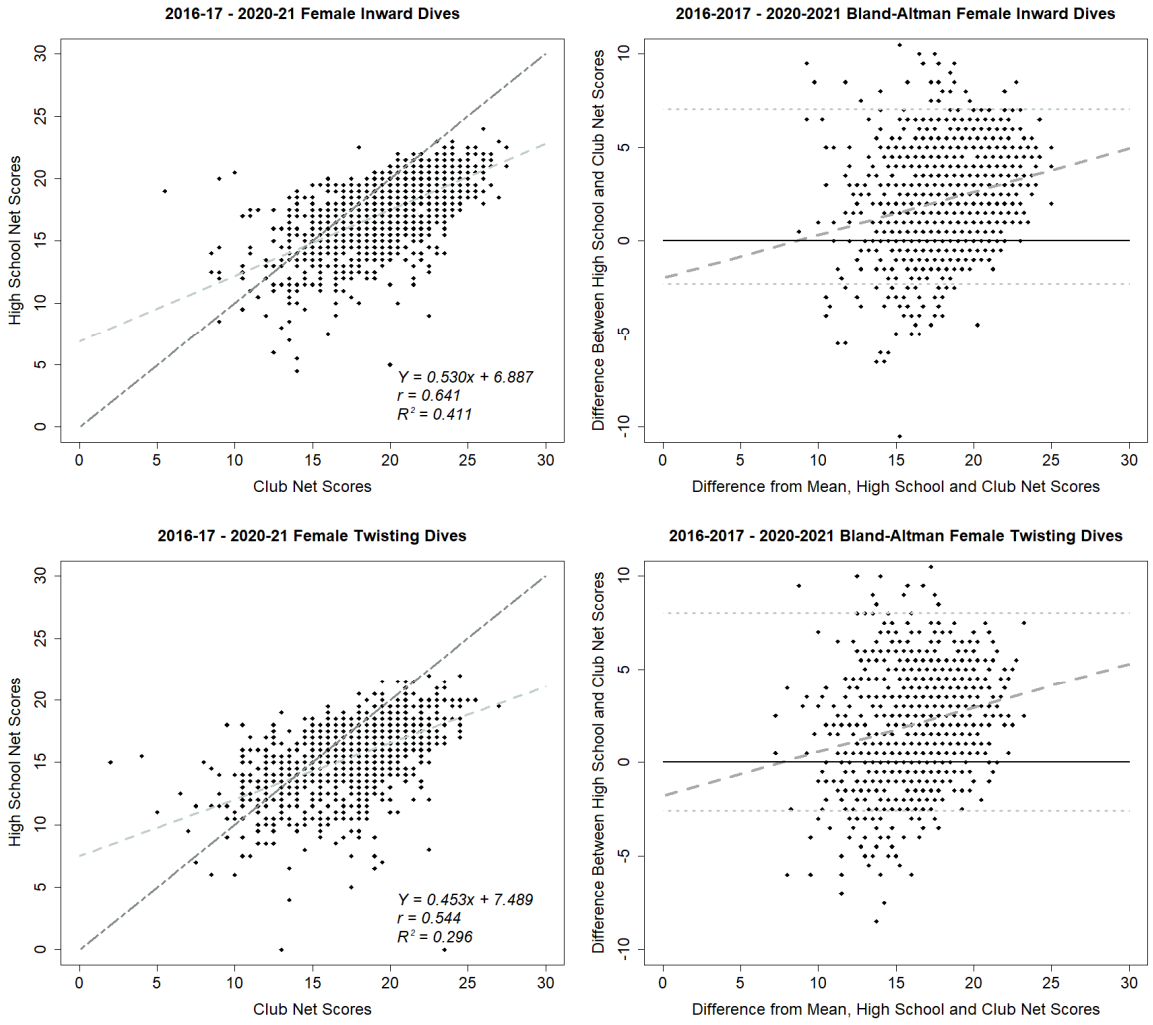
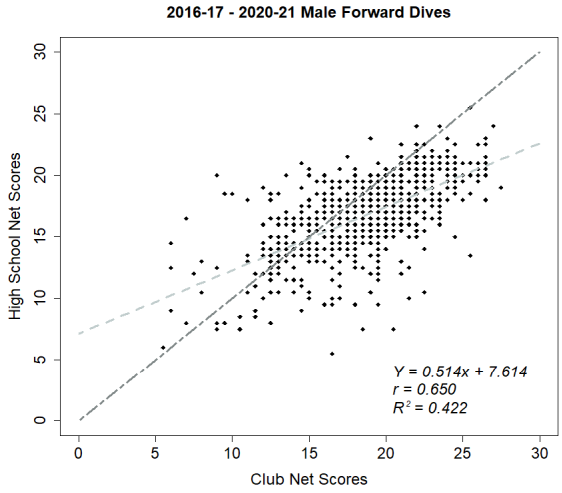
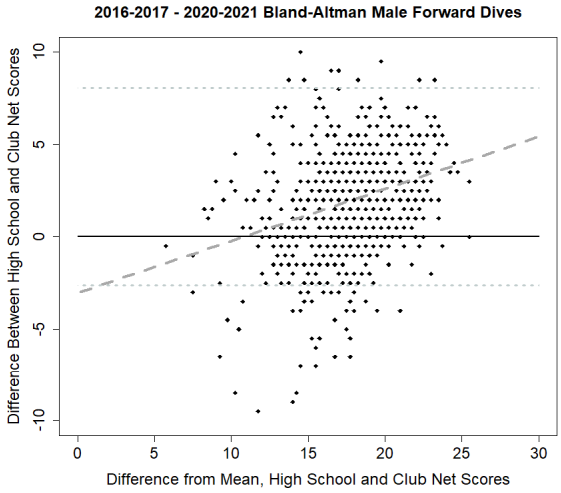


Figure 1.

On the left, scatterplots for the 2016-2017 through 2020-2021 seasons for Female divers. On the right, Bland-Altman plots for the same sub-groups. Differences within each dive for club and high school net scores are on the X-axis. Differences from the mean are on the Y-axis.


2016-17 - 2020-21 Male Forward Dives
High School Net Scores
Club Net Scores
Y = 0.514x + 7.614
r = 0.650
R² = 0.422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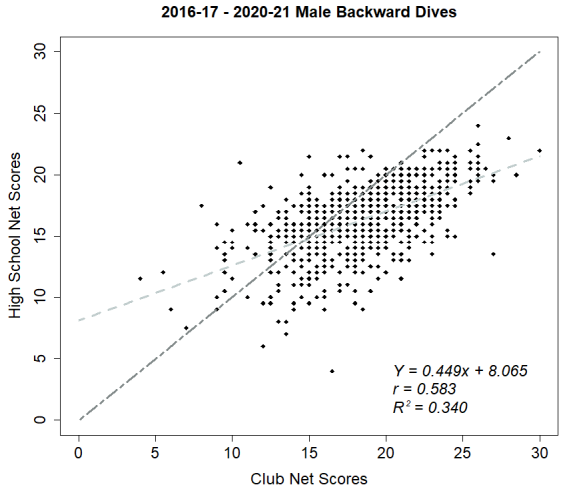
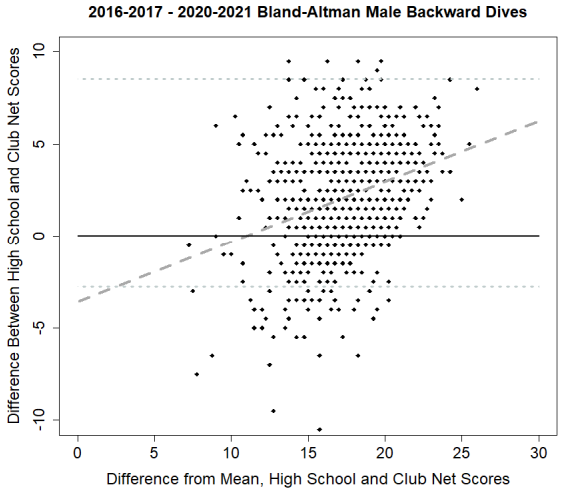
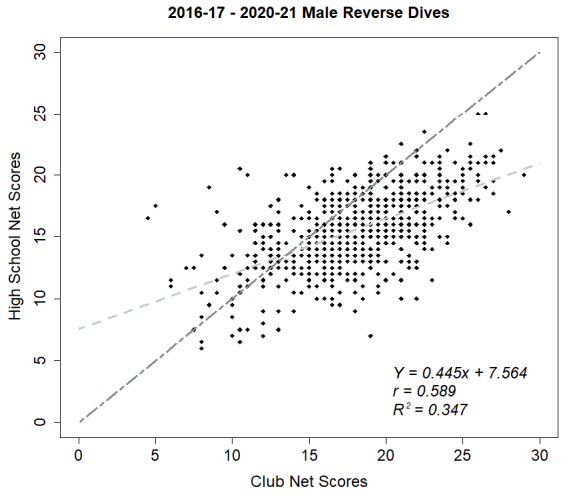
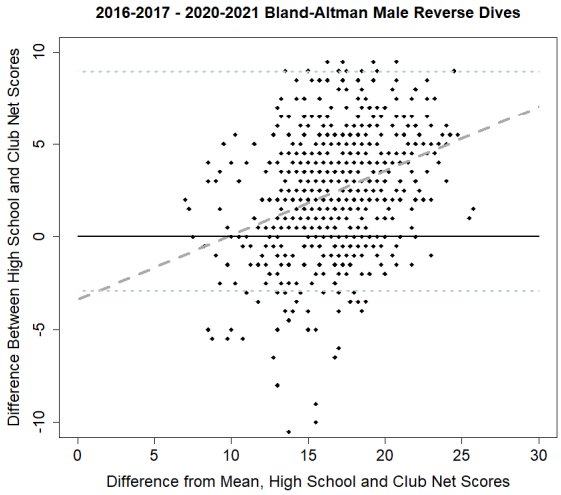
Difference Between High School and Club Net Scores
Difference from Mean, High School and Club Net Scores


2016-17 - 2020-21 Male Backward Dives
High School Net Scores
Club Net Scores
Y = 0.449x + 8.065
r = 0.583
R² = 0.340


2016-2017 - 2020-2021 Bland-Altman Male Backward Dives
Difference Between High School and Club Net Scores
Difference from Mean, High School and Club Net Scores


2016-17 - 2020-21 Male Reverse Dives
High School Net Scores
Club Net Scores
Y = 0.445x + 7.564
r = 0.589
R² = 0.347


2016-2017 - 2020-2021 Bland-Altman Male Reverse Dives
Difference Between High School and Club Net Scores
Difference from Mean, High School and Club Net Scores

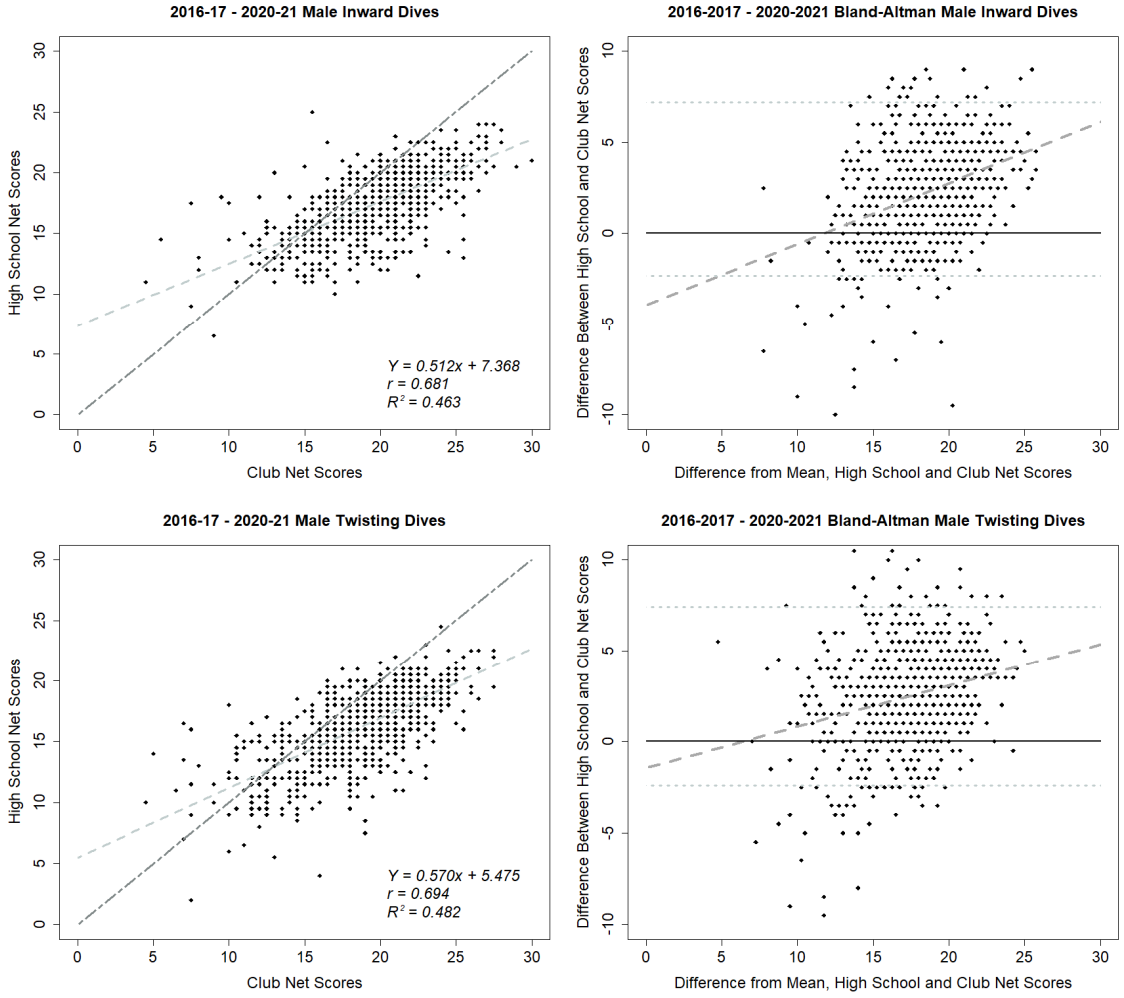


Figure 2.

On the left, scatterplots for the 2016-2017 through 2020-2021 seasons for Male divers. On the right, Bland-Altman plots for the same sub-groups. Differences within each dive for club and high school net scores are on the X-axis. Differences from the mean are on the Y-axis.

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