The Dichotomy of Sporting Potential Versus Sporting Production

Using Yield Percentage in Artistic Gymnastics

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Introduction

When it comes to sports, numbers are the proverbial fruits of a competitor's labor. All those hours spent in the gym, the pool, the track, the court and in countless other arenas, culminate to chase numbers. Whether a higher number, a lower number, an even number, or an odd number, the athletes strive for a number that separates themselves from the rest. Competitors will classify themself a champion, or not, based upon a number.

Artistic Gymnastics is no exception to these numerical designations. Our sport deals in numbers - lots of them.

We add, we subtract, we multiply, we deal with angles of the torso, the legs, the shoulders. We count elements, we monitor repetitions, we create complex spreadsheets tallying scores. We even use decimal numbers, sometimes to the thousandth place.

Elements are assigned to letters, which are assigned to decimals. A's = .1, B's = .2, C's = 0.3 … I's = 0.9 - The very definition of Algebra!

We deal with algebraic-like equations to formulate start values such as:

EDDDCCCA + 2.0 + 0.2 + 10.0

Judges are required to get these equation-like sequences correct within time limits. Take a Women's Judging exam to become an International Brevet Judge and its 45 seconds!

Not to inflate your intelligence but I bet 99% of you got the algebraic equation above correct – 14.9, of course. In the field of play, if a judge is within the 1% to get it wrong, they will receive a protest, and someone pays money to get them to review their answer. More numbers (*and now money*)!

It is safe to say, our sport is immersed in calculations of numbers. One could postulate that coach education should require a mathematical component and judge recruitment should seek out accountants and statisticians.

Creating rules that bind these numbers together must be incredibly complex. How do you logically create a number system that correctly identifies the physical make up and aesthetic qualities a gymnastic champion should possess based upon his, or her, performance?

Codes of Point's (COP's) seek to accomplish the prodigious task of categorizing performances into logical rankings. In Artistic Gymnastics, the COP's come in two versions, Men's Artistic

Gymnastics (MAG) and Women's Artistic Gymnastics (WAG). The content of both the current 2022 - 2024 codes totals 444 pages of rules, 172 pages of MAG and 272 pages of WAG. Of course, these codes are not comprehensive given the copious newsletters, additions, amendments, and clarifications distributed throughout the quadrennium.

The most recognizable number in gymnastics is undoubtedly the "Perfect 10.0". Is there anything more satisfying than a notation that is "perfect" when it comes to numbers? The "Perfect 10" was the highly sought-after number inside a scoring system known as a closed system. After 125 years of existence (1881 – 2006), the Federation of International Gymnastics (FIG), led at the time by Bruno Grandi (†), decided this perfect notation would be left "down under" at the conclusion of the 2005 World Championships in Melbourne, Australia. It should be noted that many federations still use a closed system. Post Melbourne came a new era for FIG sanctioned scoring – the open-ended scoring system.

With this immense change, quantifiable numbers used to establish champions now had no limit...

This paper aims to advocate the use of a metric labelled yield percentage to enhance performance strategies in Artistic Gymnastics. Using yield percentage, participants can consolidate the vast amount of numbers in our sport towards devising successful analytical strategies. Coaches, judges and administrators can use the metric of yield percentage to better select teams, better predict reliability and better understand progressive trends within a competitor's, and/or a team's performance.

Yield as a metric is used extensively in analytical analysis in a wide variety of industries, why not gymnastics? To formulate an answer we must first scratch the surface of statistics in sports.

Statistics in Sports

Based on a true story, the 2011 film *Moneyball*, chronicled the 2002 Oakland A's as they built a team of undervalued talent by using a sophisticated sabermetric approach to scout and analyze players performance. Sabermetrics is the empirical analysis of baseball, especially baseball statistics that measure in-game activity.

Moneyball dramatized the successfully avant-garde way the General Manager and the coaching team scouted the 2002 Major League Baseball (MLB) season. The 2002 Oakland A's created success by ignoring all other factors and exclusively selected a team based upon on-base percentage (OBP). This exclusively sabermetric approach, led to a 20-game win streak, tied for 5th

all time in MLB's longest win streaks of any team leading them to finish first in the American League West.

Moneyball highlighted one of many different examples in a landscape of statistical analysis in sports. Much like baseball, gymnastics has a lot of statistics. Relative to most other professional sports, gymnastics underutilizes analytical analysis of these statistics. Most professional sports are currently using data and statistics to predict, strategize and monitor progress. A large portion of professional teams draw upon the expertise of professional statisticians to support their endeavors. The MLB has sabermetrics, the NFL has TQR, DVOA, the NBA has WARP (*Google them if you are curious*).

Could using metrics and analytics provide the same type of opportunity and perspective for successful gymnastics performance? We certainly have a tremendous assemblance of numbers to work with. But what could we examine and how could we do it? Furthermore, are professionals in the competitive arena using all this information effectively?

Analytical Analysis in Sports: Using Metrics to Develop Key Performance Indicators

When it comes to making decisions that aim at predicting and measuring performance, using metrics to develop Key Performance Indicator's (KPI's) is unequivocally the gold standard in making things happen - hopefully, in the right direction!

Successful programs should take available data and formulate KPI's to strategize objectives, a process commonly referred to as analytical analysis. There is a plethora of data, or metrics, available to the gymnastics community including, but certainly not limited to, D and E Scores, final scores, team scores, apparatus scores, high scores, average scores, deductions, physical norms, rate of perceived exertion, age, demographics, etc.

Are we performing the best given our resources? Do we need higher D Scores? Should we look to stabilize performances to elevate Final Scores? Should we use a Double Layout with a Full Twist as opposed to a Double Layout with a Double Twist off High Bar for the sake of one tenth of extra D Score? Would investing more time on a certain apparatus lead to a better overall score production? Etc.

The answers to these questions become the gold medal answers, pardon the pun.

Analytical Analysis in Gymnastics

The vast number of statistics available in gymnastics allow an opportunity to pick up a scalpel, analyze and then strategies logically without subjectivity.

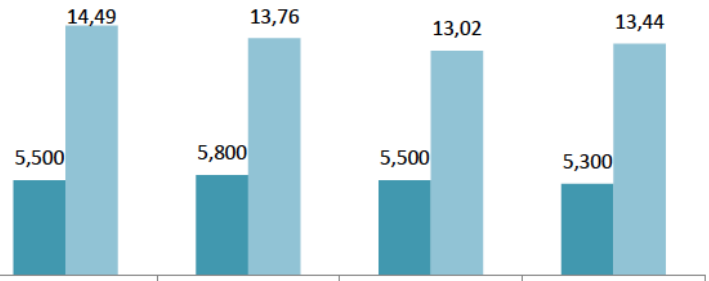
Here is an example, in the WAG FIG Newsletter #44, there are 19 pages of statistical analysis from the 2019 World Championships in Stuttgart, Germany. Newsletter #44 includes metrics ranging from age statistics, comparisons of average D Scores, comparisons of average E Scores, comparisons of averages across apparatus, comparisons from Qualifications, comparisons from Team Finals, from All Around Finals and from Apparatus Finals. There were even comparisons of all these statistics against previous World Championship years within the quadrennium (2017 & 2018).

Looking at newsletter #44 through the lens of analytical analysis, we gain an understanding that out of 259 female competitors in the 2019 WC's, the average age was 19.93. Since the inception of the open-ended code in 2006, the average age of female competitors has risen from 18.2 years of age in the 2005 WC's, to 19.93 in 2019. From this comparison, federations could strategize what age to peak their athletes in contemporary high-performance gymnastics.

To put it simply, programs should be strategizing on how to support older female athletes. Would 'life-style coaches' become important assets within a national team's support staff given the average female at world level is no longer an underaged girl? Would investment in elite performance within university level hierarchies become more important? These are questions using analytical analysis that could lead to potential breakthroughs for federations.

Let's further utilize analytical analysis alongside the information included in Newsletter #44. Pictured below are difficulty scores (D-Score) alongside final scores from the 2019 World Championship, WAG Team Final:

Comparison of average D-score/ final score – all 4 apparatus in the Team final:



	VT	UB	BB	FX
D-score	5,5	5,8	5,5	5,3
Final Score	14,494	13,755	13,019	13,439

Federations could strategize to elevate difficulty scores to be competitive amongst the top teams. If an athlete, or team, does not have the appropriate difficulty to compete with the averages of the team finalists pictured above, they need to implement an analytical strategy to elevate these values. Perhaps bringing in a technical expert to assist in new skill development or elicit advice from a Brevet Judge to assist with routine construction. The KPI would aim to elevate the average difficulty score of the team by the next World Championship should they desire to be competitive amongst the best teams in the world.

Alternatively, programs might strategize to lower their difficulty scores in an effort to stabilize performance consistency to elevate their final scores. Again, through strategies such as collaborating with a Brevet judge or a Sport Psychologist, consistency could be stabilized. The KPI would aim to elevate the final score through hitting routines consistently as opposed to elevating start values.

Taking metrics, and developing KPI's is paramount to achieving goals and targets on the road to success in any sport, let alone Artistic Gymnastics. After all, it was Arno Lascari who once said, "To call an athlete a "winner" is often a better compliment than calling him an "artist". Striving to win is the focus of athletic competition."

Potential vs Production

In competitive sport, an outcome, or result, boils down to the potential an athlete, or team, has and what they produce, alongside a set of rules. Whether one agrees with the rules or not, is another matter unto itself.

The perfect dichotomy of potential versus production!

In the book, "Inside Sport Psychology", Peter C. Terry and Costas Karageorghis perfectly explain the polarity between potential and production in sport:

Athletes often misunderstand this component of performance and use the term skill interchangeably with terms such as ability, talent and technique. When watching a sporting event, youngsters often exclaim, "Wow! Did you see that skill?" referring to an impressive action of the field of play.

We cannot actually "see" skill. Skill is intangible, and the term refers to the capacity to produce a desired result consistently and with efficiency of time and effort. What the kids are

seeing is performance, not skill, but the two are often thought of as one and the same. A high level of skill makes successful performance more probable but does not guarantee it.

We should emphasize that a gap exists between skill level and performance level. One represents potential; the other represents production. All we can see is skilled performance, the manifestation of potential, and it is worth remembering that your performance, although undoubtedly the best indicator of your skill level, is a far-from-perfect measure of your skill.

The authors have perfectly articulated the relationship of difficulty scores, execution scores and the subsequent final scores in the contemporary open-ended scoring system. The "gap" referenced by the authors is the very definition of *performance yield*. If we convert *performance yield* to a metric labelled yield percentage, coaches obtain a powerful ability to consolidate numbers into meaningful data.

So what is yield and how can we use it?

Yield Percentage as a Metric

At its basic definition, yield is the amount of something produced. If there is a yield of 90%, this tell us there was a 10% loss of product in the production process.

Multi-million-dollar investment companies use yield to navigate investment strategies to make gains or drown in debt. Chemistry labs use yield to understand the amount of product obtained, or lost, in a chemical reaction. Manufacturers use yield to understand the amount of non-defective, or defective items, they produce.

Gymnastics should be reaping the benefits of these notations as well.

A method of notating whether a performance was successful, or unsuccessful, based upon the performers intended potential outcome, would be very valuable. What made the closed system of scoring so attractive to the average fan of gymnastics was/is its simplicity. The top score is a 10.0. When a gymnast receives a 9.0, the fan can deduce they yielded 90% of the perfect score, or they did not fulfill 10% of a perfect performance, the former sounding more optimistic than the latter!

Some critics of the open-ended code are often critical of its complexity in assessing a performance. However, yield percentage applied to an open-ended score could help simplify the optics of a contemporary (2006 onward) championship performance.

Yield percentage is found through the following formula:

$$\text{YIELD \%} = \left(\frac{\text{FINAL SCORE}}{\text{D-SCORE + MAXIMUM E-SCORE}}\right) \times 100$$

Let's look at a hypothetical example of a routine performed, assessed under an open-code system, then convert it to a yield percentage:

- Gymnast A competes a routine with the following difficulty = 3.3 (FEEDDCCC)
- Gymnast A competes all the Element Groups/Compositional Requirements = 2.0
- Gymnast A competes more than 7 Elements, therefore maximum E Score = 10.0
- E Jury Deductions from the performance total = - 2.2
- Gymnast A's Final Score = 13.1

$$85.6\% = \left(\frac{13.1}{5.3 + 10.0}\right) \times 100$$

The hypothetical routine, through the optics of yield, conveys Gymnast A performed 85.6% of what they could have produced. Explained in the opposite way, Gymnast A did not fulfill 14.4% of what they could have produced.

Chinese Taipei: From 17th to 6th by Yielding + 3.6%

Let's look at a factual example of how using yield percentage as a metric can demonstrate informative, extracurricular outcomes contrary to traditional ranking results.

In the qualification process for the Olympic Games in the 2017 – 2020 (2021) process, Chinese Taipei had a clearly defined game plan. According to a news report by the FIG, Head Coach Sadao Hamada's communicated his strategy to the world:

"*Hamada's strategy was to maximize the Execution portion of the score rather than risk adding big tricks and combinations, which would increase the Difficult part of the score.*

"I knew my guys did not have a lot of skills," he explained. "I did not have time to teach new skills with big difficulty so my strategy was whatever they can do, even the lower-level skills, they can do it cleanly." (FIG, 2019)

Over the course of one year, Hamada's team jumped from 17th in the Team Qualifications of the 2018 WC's, to 8th in the Team Qualifications of the 2019 World Championships and subsequently finishing 6th in the finals! When you examine the yield percentage alongside the scores, you can witness how Hamada's strategy unfolded.

It should be noted the team lineup for these two competitions did not change, although starting lineups per apparatus, and counting scores towards the overall team score, did. This is important as the same gymnasts were used to apply Hamada's strategy minimizing room for other contributing factors to team performance with different performers.

The gymnasts for Chinese Taipei for both World Championships were: HSU Ping Chien, LEE Chih Kai, SHIAO Yu Jan, TANG Chia-Hung, YU Chao Wei

Here are the yield percentage from these two competitions:

Qualifications WC 2018					
Team	Rank	Final Score	D Score	Yield %	Yield % Rank
Russia	1	258.402	287.9	89.75%	2
China	2	257.836	286.6	89.96%	1
Japan	3	253.312	287.4	88.14%	6
USA	4	250.362	282.1	88.75%	3
Great Britain	5	249.836	282.3	88.50%	5
Brazil	6	246.961	280.4	88.07%	7
Netherlands	7	245.663	277.4	88.56%	4
Switzerland	8	245.186	279.6	87.69%	10
Ukraine	9	243.651	280.6	86.83%	14
Germany	10	241.935	281	86.10%	17
Spain	11	241.261	275.5	87.57%	11
France	12	241.203	275	87.71%	9
Korea	13	240.844	277	86.95%	13
Italy	14	240.763	275.6	87.36%	12
Turkey	15	240.196	278.3	86.31%	16
Kazakhstan	16	239.291	271.7	88.07%	8
Chinese Taipei	17	238.195	275.5	86.46%	15

Qualifications WC 2019					
Team	Rank	Final Score	D Score	Yield %	Yield % Rank
Russia	1	259.928	288.5	90.10%	1
China	2	258.354	288.2	89.64%	5
Japan	3	258.026	287.3	89.81%	3
Ukraine	4	253.528	283.2	89.52%	7
Great Britain	5	252.409	283.4	89.06%	8
Switzerland	6	251.4	280.8	89.53%	6
USA	7	250.359	281.6	88.91%	10
Chinese Taipai	8	250.093	277.7	90.06%	2
Korea	9	249.651	280.9	88.88%	11
Brazil	10	247.236	279.9	88.33%	15
Spain	11	246.727	278.1	88.72%	13
Germany	12	246.508	279.2	88.29%	16
Italy	13	245.996	276.3	89.03%	9
France	14	245.127	273.3	89.69%	4
Turkey	15	244.652	276.9	88.35%	14
Kazakhstan	16	243.897	274.6	88.82%	12
Canada	17	242.328	276.9	87.51%	17

Based on the tables, in 2018, Chinese Taipei was 15th overall in yield percentage rank with 86.46%, finishing 17th overall in final score rankings. The following year, Hamada's strategy to "do it cleanly" was clearly accomplished as the team finished 2nd overall in yield ranking with a yield percentage totaling 90.06%. In one year, a yield percentage difference of + 3.6% points equated to an 11.898-point final score improvement!

Applying Yield Percentage

In the example of Chinese Taipei, the application of yield percentage was retrospectively utilized. “Hindsight is 20,20”, as the saying goes. The point was to demonstrate the process of how to find yield percentage when using a different approach to quantifying performances outside of traditional final score rankings.

Now, we must demonstrate how to use yield percentage to strategize, create targets and hopefully increase probabilities of success.

In the book, “How to Create Champions”, Leonid Arkaev overviews zones of mastery in the technical preparation of gymnasts. These five zones are:

1. *Small – Training by elements*
2. *Medium – Training by series, or combinations*
3. *Big – Training by routines*
4. *Sub-Maximum – Training by routines in a competition regime*
5. *Maximum – Training by routines in a regime exceeding the competition.*

These zones of mastery are commonly used all over the world to progressively prepare gymnasts for competition. Some call these zones a wide variety of different descriptions; single elements, parts, combinations, half routines, 1/3 routines, watered down routines, skeleton routines, etc.

Arkaev explains, “*The extent of mastery of each zone of intensity has two indicators: mean assessment (m) and performance reliability (R) which may be expressed in the formula: R = n/N. Where **n** is the number of successfully performed exercises, and **N** is the number of attempts at performing the given exercise (element, series or routine). In each zone of intensity there are five levels of mastery:*

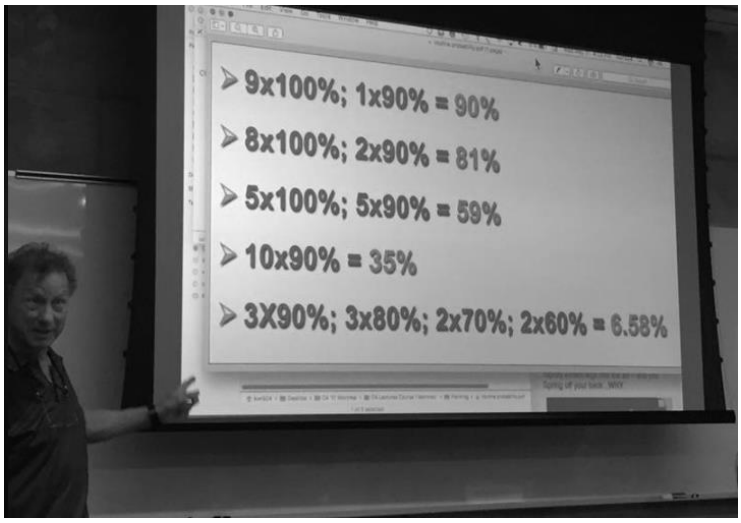
1. *Mean mark is 1 with reliability of up to 0.2*
2. *Mean mark is 2 with reliability of up to 0.2 - 0.4*
3. *Mean mark is 3 with reliability of up to 0.4 - 0.6*
4. *Mean mark is 4 with reliability of up to 0.6 - 0.8*
5. *Mean mark is 5 with reliability of up to 0.8 - 1.0*

We recommend mastering the following zone of intensity after reaching indicators of the fourth level of mastery of the previous zone on condition that conservative technical faults are absent”

Recommending gymnasts not progress until they have mastered the fourth level of mastery, or between 0.6 - 0.8 (60 – 80%), Arkaev created an easily understood target. His process is clear, master a given task with an individual skill of 60 – 80% reliability > master the same individual skill inside a combination of 60 – 80% reliability > master the same individual skill inside a routine 60% - 80% and so forth and so on, shuttling in and out of zones of mastery until you create reliable, predictable, and successful performances.

Arkaev's R = n/N formula **is** a measure of yield notated as a decimal between 0.0 - 1.0. Reliability (R) equals how many times you could have been successful (potential, or n) versus how many times you were successful (production, or N). Converting this decimal to yield percentage is simply a matter of multiplying by 100.

When applied to every skill in a routine a portrait of reliability can certainly be painted. Keith Russell, the head of the FIG Scientific Commission, demonstrates this reliability at work in the following picture. If 9 skills in a routine are yielding 100% reliability, and 1 skill is 90% reliable, the 10-skill routine is 90% reliable. 8 skills, 100% reliable and 2 skills, 90% reliable, the 10-skill routine is 81% reliable. And, so forth, and so on.



Through everyday tracking of successful repetitions versus non-successful repetitions, coaches can calculate the mean of data to produce a concise portrait of how reliable a gymnast is at a given task. The key would be to track and record, then monitor and devise strategies to improve.

Conclusion

When it comes to sports, every so often a performance obtains sieve-like differences between what an athlete can do and what they end up consistently producing in the field of play. This difference in production expressed as a percentage is a yield percentage. If one could create an athlete, or team of athletes, that could produce performances exactly congruent with what their potential is, they would accomplish the impossible.

As it is impossible to create such a feat, participants should understand yield and its ability to strategize towards more reliable performances. It is a reliability on what one can produce in the field of play that creates the best opportunity to succeed in sports performances.

It is hoped the reader gained an appreciation for how to work alongside all the statistics gymnastics has using analytical analysis. With all the statistics available, coaches, gymnasts and administrators need a methodology to consolidate these numbers into easily understood processes – yield percentage could be one tool at their disposal.

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