

Performance, Privacy, and the Professional: The
Proliferation of Data Analytics in Athletics

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The explosion of data has transformed many industries. Healthcare, banking, retail, manufacturing, and technology are among the domains impacted by data analytics. Athletics, in particular, has been reshaped by recent technology advancements. Ramon Alonso, holder of the sports telemetry system patent, says that the “gathering, processing, and use of data and statistics are an important aspect of the business, analysis, and appreciation of sports” (Alonso, 2012). The publication of the book *Moneyball* (Lewis, 2003) sparked a new national appreciation for sports analytics, evident in “Fantasy” leagues, sports betting, and commercial sensors such as Fitbit. Fantasy leagues had a total revenue in 2018 of 7.7 billion dollars, with an annual growth rate of 8 percent over the previous five years (Gambardella, 2018). As for personal health trackers, FitBit posted a 1.51 billion dollar revenue in 2018 (FitBit, 2019), and the Apple Watch posted 5.1 billion dollars in revenue (Miller, 2019). People are more concerned with data than ever, whether it be box statistics for sports betting or biometric data for personal improvement.

Participants in this research study include the athletes represented by the National College Players Association (NCPA, 2019), athletes represented by any professional league across the globe, coaches and trainers (NCAA, 2018), sports analysts (Jahnke, 2019), and sports fans (ESPN, 2019). College athletes are represented by the National College Players Association, which seeks to “protect future, current, and former college athletes.” According to Katie Yentz, a men’s hockey analyst at Boston University, the goal of sports analysts is to “help the coach know the team as well as he can,” so as to “*objectively* assess strengths and weaknesses” (Jahnke,

2019). The NCAA claims that coaches “mentor college athletes” (NCAA, 2018). Sports fans are evidently interested in the statistics, as ESPN provides constant data on its website.

While data analytics in sports offers many benefits to players, teams, and fans, it divides groups over its impact on privacy and its digitization of the game. As analytics capabilities develop, controversies over data collection and usage ensue. Biometric and performance data in athletics threatens athletes’ personal privacy. Some athletes may be traded or faulted on the basis of their biometric health data. Coaches will support analytics if it helps them improve. Can data analytics replace human expertise in sports, or merely supplement it? Groups are divided over such questions.

Review of Research

Research about sports analytics has increased as capabilities continue to grow and more teams use data analytics for their sport. There is a 50+ year history of operations research in sports (Wright, 2009). Yet more recently, publications have surfaced such as the *Journal of Quantitative Analysis in Sports (JQAS)* in 2005, the *Journal of Sports Economics (JSE)* in 2000, and the *International Journal of Sports Science and Engineering (IJSSE)* in 2007, all indicating a greater interest in sports analytic research (Coleman, 2012). *JQAS* includes many articles on results from statistical research on sports such as “Identifying NCAA Tournament Upsets using Balance Optimization Subset” (Dutta, Jacobson & Saupe. 2017), but seem to lack content on the research’s societal impact. *JSE* includes more on sport participation and societal determinants, while *IJSSE* has comparable content to *JQAS*, yet has not published since September 2013 (S-SCI, 2014).

There exists extensive published research and discussion on data and surveillance, relating to various aspects of civilization. For example, in “*Big Data Surveillance: The Case of Policing*” (Brayne, 2017), a theoretical model of big data surveillance is developed that is applicable to institutional domains other than the Los Angeles Police Department. This research paper will apply these theories to sports in order to understand its impact on performance, privacy, and professionalism.

The analysis in this paper will use the research published in the journals previously mentioned, as well as publications not formally associated with a sports analytics journal. The use of statistical analysis from these technical pieces will repute some of the opinions represented. Aside from scientific publications, this paper will use the voices of its participants, namely athletes, fans, and coaches, to both defend and oppose data analytics in sports. Combining these distinct sources will create a novel analysis that undermines the social impact of growing technology on sports.

Players, Coaches, and Analysts can Benefit from Data Analytics in Sports

The rapid growth of data analytics has created new opportunities for organizations across the globe. According to a Deloitte Access Economics report, the world creates an additional 2.5 *quintillion* bytes of data every year, and this data is infiltrating across many industries such as finance, healthcare, general sciences, cybersecurity, defense, and agriculture (Deloitte, 2018). Thus, the sports industry, including players, coaches, and analysts, has turned to data analytics in recent years to reap its benefits.

Players can use analytics to their advantage. Brandon McCarthy, once a pitcher for the Arizona Diamondbacks, began to study his own statistics relative to those of successful pitchers,

and improved his performance enough to receive a better contract offer with the Oakland Athletics (Davenport, 2014). Another analytic advantage to players is injury prevention, which can be better understood through monitoring training load. New load monitoring techniques include using heart rate monitors and tools to track data. According to Shona Halson, a researcher at the Australian Institute of Sports, athletes who monitor their own training data feel more empowerment and ownership (Halson, 2014). When athletes communicate about the data with training staff, confidence in the program can grow. For example, after implementing analytics, the Seattle Sounders saw a 67 percent reduction in game days lost due to muscle injury from 2012 to 2014 (Karkazis & Fishman, 2017). With fewer players out due to injury, teams can improve their season. Popular companies such as Catapult and Kitman Labs claim that there is a 20-33 percent reduction in injury rates in teams that implement their technology. These reductions in injury rates take time, however, because it can be difficult for a coach to decide that a seemingly fit player may need to rest based on the data from wearable technology (Innovation Enterprise, 2017).

Coaches can benefit from accessible data as it relates to recruiting. At the University of Virginia, students in the engineering school created a database of over 53,000 football recruits and 200 predictive attributes in order to model important aspects of collegiate football recruiting (SIEDS, 2019). They believe that their platform will give the Virginia football recruiting staff a competitive advantage. Similar athletics databases include the world's largest baseball scouting service, Perfect Game USA. Such databases are changing how coaches seek talent. According to Les Edgerton, instead of traveling across the country to watch high school games and practices, coaches and scouts can simply check a player's showcase statistics on Perfect Game USA's website (Odgen, 2010). As of 2009, the website contained data on over 25,000 players in the US.

Now, it has contributed to the selection of 1,369 Major League Baseball (MLB) players and 12,626 MLB Draft Selections (Odgen, 2010). Perfect Game USA's mission is to "Promote the game of baseball now and in the future by ... providing meaningful opportunities and information to players, families, MLB organizations, college coaches, and fans" (Perfect Game USA, 2020).

Sports analysts claim data analysis is an indispensable tool for team performance, individual improvement, injury prevention, and fan base growth. For example, analyst Ray Hensberger used Major League Baseball data in a machine learning model to predict pitching behavior during games with 74.5 percent accuracy (Fried & Mumco, 2017). Some analysts see the potential to start their own analytic services to help sports teams. Sports Info Solutions (SIS), formerly Baseball Info Solutions, has been delivering sport data and analysis for nearly two decades to customers (Dewan, 2020). According to their website, "SIS captures statistical snapshots of every on-field event. This produced an exhaustive database that includes traditional statistics and advanced analysis. SIS has leveraged this database to assemble extensive pitch-charting and defensive data". In the last 5 seasons, the company has more than tripled its full-time staff (Dewan, 2020). Sports analysts like John Dewan, the founder of SIS, require the collection of data from athletes for their businesses.

The growth of the job title "data scientist" is indicative of its demand across industries. Between 2016-2017 and 2021-2022 the forecast annual growth in data science professionals is 2.4 percent (Deloitte, 2018). LinkedIn reported that statistical analysis and data mining was the second ranked most in-demand skill in job advertisements in 2016 (Murthy, 2016). With more sports data available, these highly demanded "data scientists" can work with professional and collegiate teams to improve their training and performance. Subsequently, more job

opportunities are created for students interested in science, technology, engineering, and mathematics.

The Impact on Sports Betting

Modeling techniques in sports are doing more than improving performance. When the United States Supreme Court ruled sports betting legal in May 2018 (Licata, 2019), new opportunities for sports analysts and data engineers erupted. Experts estimate the potential revenue from this market to be about \$150 billion (Bucquet & Sarukkai, 2018). John Fries, vice president of development at Exadel, claims that sports betting "...has the potential to be one of the most important, publicly visible test cases for digital transformation that we've seen to-date" (Fries, 2018). Sports betting requires real-time, accurate data for players, teams, and games from nearly all professional sports. This data must also be available in a way that is easy for the average sports bettors to consume. But the collection of professional athletes' data for sports betting may not stop at these public box statistics, private data may be shared through online betting sites.

Data has become essential to the sports betting industry. Therefore, whoever controls the data, controls how the industry works (Glanz & Armendariz, 2018). Data thieves are now attending sporting events in hopes of scouting the game time data in an unofficial manner (Glanz & Armendariz, 2018). Aside from game time data, wearable technology could have an impact on sports betting. Bettors could decide who to place on their Fantasy League lineup based on their perceived exhaustion from wearable tech. For example, someone could choose to bench one of their Fantasy Football running backs because of a faulty heart rate data point, even though they physically feel at their best. Morgan Lewis says that this "raises serious privacy concerns for the

athletes that could spill over into an athlete's ability to negotiate a contract or endorsement deal" (Fogel, 2020).

Another concern emerging from the legalization of sports betting in the U.S. is how it could change American sports nature. Legal sports betting, combined with increased technology and analytics, could make the sports industry even more commercialized. Ed Piccioto posted his opinion online of the consequences of legal sports betting, saying, "In a slow but consistent process, the focus of American sports will become betting rather than the game itself. Anyone who has ever gambled on a sporting event knows that once you place a bet, the focus of the game suddenly becomes money, not the game itself. And that's not what sports is about" (Piccioto, 2018).

Intrusion on the Athlete's Privacy and Evaluation Methods

Data analytics requires consistent monitoring, which can be intrusive to an athlete. According to the Karkazis and Fishman (2017), "there are few regulations governing the use of biometric devices in professional sports." Thus, some athlete data could harm the athlete's employment prospects (Osborne & Cunningham, 2017). Alex Ferguson, British soccer manager, traded his defender, Jaap Stam, due to match data. He later called it the "biggest mistake of his career" (Anderson & Sally, 2014). Analytics serves manifest and latent functions (Merton, 1949). The manifest function is to improve a team's overall game performance; a latent function is to evaluate players.

Some college athletes may not trust the data produced by wearable sensors and what is done with it. At the University of Michigan, a \$170 million contract allowed Nike to collect data from the student-athletes wearing their sensors. A hidden clause grants Nike "the right to utilize ... Activity Based Information ... in any and all media" (Nike & Michigan, 2016). While

analytics can enhance performance, it can also threaten privacy and damage relationships.

University of Virginia Men's Soccer trainer Peter Alston claims he wants to build an honest relationship with his players – one where he can trust their self-reported data regarding hours of sleep and stress levels (Alston, 2019). Requiring student athletes to wear sensors, such as Nike's, may break this trust.

Social media is a different form of data collection that is largely affecting the college recruiting process. The model that was created for the University of Virginia's football program uses social media analyses in addition to published performance data to recruit the best players for their team (*SIEDS*, 2019). Many schools and professional teams are turning towards platforms such as Twitter and Instagram to gather information about potential recruits. Athletes have lost offers or scholarships based on a poor social media decision (Crabtree, 2016). Shedrick McCall III, a star running back from Chesterfield, Virginia, lost his Division 1 scholarship to Old Dominion when recruiters found a YouTube video that he posted of him trespassing and using profane language (Ryan, 2019). Some coaches, including P.J. Fleck, would even like to hire a private investigator for recruiting purposes; however, that is not permitted by the NCAA (Ryan, 2019). Organizations such as the Next College Student Athlete have begun to post resources on how to use social media effectively for recruiting (NCSA, n.d.). John Kuceyski, director of scouting for Iowa State football, says, "If you want to be a good recruiter in today's college football, you have to be on [social media]. If you're not doing it, you're going to get beat by somebody that's doing it" (Crabtree, 2016). Some say it's not fair that high school students aspiring to be a college athlete must strictly filter their social media activity. But others claim it is a valuable and necessary tool for recruiters to determine what players will fit best on their team.

Data Analytics Cannot Replace the Human Expert

Some contend that data collection and automation can be dangerous when it marginalizes the human expert. To those critics, data analytics is no better than traditional coaching. They argue that they do not need advanced technology to improve their players' performance, and that because sports situations are unique, they cannot be reduced to numbers (Morgulev, 2018). A good coach must know a player's mental state, personal life, and relationship to competitors require human expertise. This conflict is embodied in the career of Parag Marathe, chief operating officer for the San Francisco 49ers. Marathe, a Stanford MBA and former Bain consultant with extensive analytics experience, has been disparaged as not a pure "football guy" (Morgulev, 2019).

As artificial intelligence capacities grow, professional complications emerge in industries other than sports. A similar phenomenon is occurring in healthcare. Because of the Health Information Technology for Economic and Clinical Health Act of 2009, electronic health records (EHR) are more readily available, resulting in more healthcare providers seeking to improve clinical processes by adopting EHR (Neil, 2013). Some advocates of the growth of information technology in healthcare say that this is essential to improving the quality and lowering the cost of patient care (Neil, 2013). However, other healthcare specialists fear that the electronic records create an "electronic patient" that could become the focus for doctors, as opposed to the physical patient themselves (Verghese, 2011).

While it is a very dynamic issue, the rise of COVID-19 around the world in 2020 has turned many doctors, businesses, and politicians to data analytics. Tracking the spread of a virus can be difficult in real time, especially when there is a lack of testing resources. However, Kinsa

Health, a company that uses internet-connected thermometers to immediately send temperature readings to the cloud, says it is tracking the coronavirus in real time (McNeil, 2020). Kinsa Health's interactive map showed a decreasing trend in coronavirus symptoms across the U.S. as of March 25th, 2020 (Kinsa, 2020). Yet, they listed a warning on their website saying, "We are not stating that this data represents COVID-19 activity... Taken together with other data points, we believe this data may be a helpful early indicator of where and how quickly the virus is spreading" (Kinsa, 2020). In a crisis like this, it is integral to not rely on only big data analyses to answer every question. The human expert, in this case the Center for Disease Control (CDC) or World Health Organization (WHO), is essential in decision making.

These healthcare and global dilemmas are analogous to sports. In healthcare, some people may distrust big data or artificial intelligence, preferring a doctor's, or the CDC's, diagnosis. In sports, some players may distrust the data analytics, preferring human experts in athletics. Beyond distrust of data analytics and artificial intelligence, some fear that it will ruin professional sports. Jayson Werth, a recently retired player on the Philadelphia Phillies, said in a podcast interview, "I think it's killing the game. It's to the point where [we could] just put computers out there" (Timms, 2018). Another famous baseball player for the New York Yankees, Richard Gossage, was even more hostile. "The game is becoming a freaking joke because of the nerds who are running it. I'll tell you what has happened, these guys played rotisserie baseball at Harvard or wherever the fuck they went, and they thought they figured the fucking game out. They don't know shit," said Gossage (Timms, 2018). Clearly, athletes and fans are passionately divided over the effect of technology on sports.

This divide does not appear to be stopping these "nerds" from getting jobs with important professional teams. Paul DePodesta, one of the key figures in *Moneyball* (Lewis, 2003), who

graduated from Harvard with a degree in economics and no sports background, has held top positions on multiple MLB teams. More recently, he has made headlines by leaving the New York Mets for a new team and sport. He is now the chief strategy officer for the NFL's Cleveland Browns, moving from a job in baseball to one of the top executive positions in professional football (Baumann, 2019). Perhaps the disagreements over sports expertise and analytic talent will ensure that the sports industry does not become overrun by technology and data.

Conclusion

In recent years, the term “data analytics” is frequently referenced as the innovative solution to an industry’s problem. Whether that is analyzing CT scans for early signs of tumors (T.G., 2018), developing an algorithm for risk assessment of criminals (EPIC, 2017), or predicting how well a high school baseball player will be in 4 years, “data analytics” often has a positive connotation.

While it is true that new technology can be efficacious in many industries, those who oppose its implications must be heard. The growth of analytic capabilities in sports, while beneficial for performance improvement, may incur a loss of both sport expertise and data privacy. Student athletes can improve their individual and team performance, but at the cost of their privacy. New and massive industries like sports betting can grow, but data security and American sports nature can be lost. Data scientists can seek new jobs in the sports industry, but some sports experts may become frustrated. Future research on data analytics in sports is necessary as technology rapidly evolves. The industry could be entirely different 10 years from now, with even more data available and ways to use it. Indeed, data analytics can assist with

many of the world's modern problems. But it cannot solve them. Data analytics is an effective tool when used together with the knowledge of the human expert and considering all privacy concerns.

References

- About Perfect Game: Perfect Game USA. (2020, Jan.). www.perfectgame.org/AboutPG.aspx
- Alonso, R. A. (2012). *United States Patent No. US8477046B2*. patents.google.com/patent/US8477046B2/en
- Alston, Peter (2019, Oct.). Personal Communication
- Anderson, Chris & Sally, David (2014). *The Numbers Game: Why Everything You Know About Soccer is Wrong*. New York, New York: Penguin Books
- Baumann, M. (2019, Aug. 23). How the Browns and Paul DePodesta Brought Moneyball to the NFL. www.theringer.com/nfl-preview/2019/8/23/20829352/paul-depodesta-cleveland-browns-oakland-athletics-moneyball-analytics-nfl-mlb
- Beckwith, Gage, Tim Callahan, Bear Carlson, Tyler Fondren, Reid Harris, Jackie Hoege, Tykai Martin, Collin Menna, Ella Summer, William Scherer, Chris Tuttle, Stephen Adams, (2019) “Systems Analysis for University of Virginia Football Recruiting and Performance,” *Systems and Information Engineering Design Symposium (SIEDS) 2019*, pp. 1-6, 2019.
- Brayne, S. (2017). Big Data Surveillance: The Case of Policing. *American Sociological Review*, 82(5), 977-1008. www.jstor.org/stable/26426413
- Bucquet, A., & Sarukkai, V. (n.d.). The Bank is Open: AI in Sports Gambling. cs229.stanford.edu/proj2018/report/3.pdf
- Coleman, B. (2012). Identifying the “Players” in Sports Analytics Research. *Interfaces*, 42(2), 109-118. www.jstor.org/stable/41472740
- Crabtree, J. (2016, Jan. 25). The “social” science of recruiting. www.espn.com/college-football/recruiting/story/_/id/14646545/social-media-becomes-powerful-aide-dangerous-connection-recruiting
- Davenport, T. (2014). *Analytics in Sports: The New Science of Winning*. *Analytics in Sports: The New Science of Winning*. SAS Institute. www.sas.com/content/dam/SAS/en_us/doc/whitepaper2/iia-analytics-in-sports-106993.pdf
- Deloitte Access Economics. (2018, Feb.). The future of work: Occupational and education trends in data science in Australia.

www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-future-of-work-occupational-education-trends-data-science-170418.pdf

Dutta, S., Jacobson, S. & Sauppe, J. (2017). Identifying NCAA tournament upsets using Balance Optimization Subset Selection. *Journal of Quantitative Analysis in Sports*, 13(2), pp. 79-93. doi:10.1515/jqas-2016-0062

Neill, D.B. (2013) Using Artificial Intelligence to Improve Hospital Inpatient Care, *IEEE Intelligent Systems*, vol. 28, no. 2, pp. 92-95, March-April

Dewan, J. (2020). About Us. www.sportsinfosolutions.com/aboutus/

EPIC (2017). Algorithms in the Criminal Justice System. epic.org/algorithmic-transparency/crim-justice

ESPN Enterprises, Inc. (2019). Serving sports fans. Anytime. Anywhere. www.espn.com/.

FitBit (2019, Feb. 27). Fitbit Reports \$571 Million Q4'18 Revenue and \$1.51 Billion FY'18 Revenue. investor.fitbit.com/press/press-releases/press-release-details/2019/Fitbit-Reports-571-Million-Q418-Revenue-and-151-Billion-FY18-Revenue/

Fogel, B. D. (2020, Feb. 13). The Future of Sports Betting. www.morganlewis.com/pubs/the-future-of-sports-betting

Fried, Gil & Mumcu, Ceyda (2017). *Sports Analytics: A Data-Driven Approach To Sport Business and Management*. New York, New York: Routledge

Fries, J. (2018, Aug. 28). The Big Challenge for Sports Betting: Software Engineering. www.informationweek.com/big-data/the-big-challenge-for-sports-betting-software-engineering/a/d-id/1332667

Gambardella, A. (Dec., 2018). IBISWorld US Specialized Industry Report OD4577. Fantasy Sports Services. *IBISWorld* database.

Glanz, J., & Armendariz, A. (2018, July 2). When Sports Betting Is Legal, the Value of Game Data Soars. www.nytimes.com/2018/07/02/sports/sports-betting.html

Halson, S. L. (2014, Nov.). Monitoring training load to understand fatigue in athletes. www.ncbi.nlm.nih.gov/pmc/articles/PMC4213373/

Hayhurst, C. (2019, Aug.). Data Analytics Helps College Coaches and Athletes Optimize Training and Performance. *EdTech Magazine*. www.richmond.com/

Innovation Enterprise. (2017, Jan. 9). Analytics' Role In Injury Prevention: Articles: Sports. channels.theinnovationenterprise.com/articles/analytics-role-in-injury-prevention

- Jahnke, A., & Soler, C. (2019, May 1). Sports Is Now Data Science. How Did That Happen? www.bu.edu/articles/2019/sports-analytics/
- Karkazis, Katrina & Fishman, Jennifer R. (2017). Tracking U.S. Professional Athletes: The Ethics of Biometric Technologies, *The American Journal of Bioethics*, 17:1, 45-60, DOI: 10.1080/15265161.2016.1251633
- Kinsa. (2020). US Health Weather Map by Kinsa. healthweather.us
- Lewis, M. (2003). *Moneyball: The art of winning an unfair game*. New York: W.W. Norton.
- Licata, A. (2019, Aug. 2). 42 states have or are moving towards legalizing sports betting – here are the states where sports betting is legal. www.businessinsider.com/states-where-sports-betting-legal-usa-2019-7
- McElroy, W. (2019, June). UVA has had the best athletic year of any college sports program. *Richmond Times-Dispatch*. www.richmond.com
- McNeil, D. G. (2020, March 18). Can Smart Thermometers Track the Spread of the Coronavirus? www.nytimes.com/2020/03/18/health/coronavirus-fever-thermometers.html
- Merton, Robert K. (1949). *Social Theory and Social Structure*. New York, New York: Free Press
- Miller, C. (2019, April 30). Apple Watch has another record quarter as Wearables business hits \$5.1 billion. 9to5mac.com/2019/04/30/apple-watch-q2-2019/
- Morgulev, E., Azar, O. H., & Lidor, R. (2018). Sports analytics and the big-data era. *International Journal of Data Science and Analytics*, 5(4). doi: 10.1007/s41060-017-0093-7
- Murthy, S. (2016). LinkedIn Official Blog. *The Top Skills of 2016*: blog.linkedin.com/2016/01/12/the-25-Skills-that-can-get-you-hired-in-2016
- NCAA (2018). National Coaches. www.ncaa.org/about/resources/leadership-development/coaches
- NCPA (2019). National Mission & Goals. www.ncpanow.org/about/mission-goals
- NCSA (n.d.). How to Use Social Media for Recruiting. www.ncsasports.org/recruiting/contacting-college-coaches/social-media
- Nike & University of Michigan (2016). *Nike-Michigan All-Sport Agreement*. www.toledoblade.com/attachment/2016/04/26/University-of-Michigan-Nike-contract-2016.pdf

- Ogden, D.C. (2010). [Review of the book *Perfect Game USA and the Future of Baseball: How the Remaking of Youth Scouting Affects the National Pastime*]. *NINE: A Journal of Baseball History and Culture* 18(2), 196-198. doi:10.1353/nin.0.0098.
- Osborne, Barbara & Cunningham, Jennie L. (2017). Legal and Ethical Implications of Athletes' Biometric Data Collection in Professional Sport, 28 MARQ. SPORTS L. REV. 37
scholarship.law.marquette.edu/sportslaw/vol28/iss1/3
- Piccio, E. D. (2018, June 6). Should sports betting be legal?
www.theperspective.com/debates/sports/sports-betting-legal/
- Ryan, S. (2019, May 31). Social media sleuthing is just a part of today's recruiting for college coaches: 'You rely on the resources you have and your intuition'.
www.chicagotribune.com/sports/college/ct-spt-college-recruiting-social-media-20180726-story.html
- Smith, B. (2019, Aug.). A Conversation with Chris Hayhurst.
EdTechMagazine. edtechmagazine.com/higher/
- S-SCI. (2014). *International Journal of Sports Science and Engineering*.
www.worldacademicunion.com/journal/SSCI/online.htm
- Timms, A. (2018, Aug. 16). Are Super-Nerds Really Ruining U.S. Sports? *The Guardian*.
www.theguardian.com/sport/2018/aug/16/sports-nerds-analytics-
- T.G. (2018). Data Analytics: Crowd Control. *ASEE Prism*, 28(2), 13-13.
doi:10.2307/26828854
- Verghese, A. (2011, Feb. 27). Treat the Patient, Not the CT Scan. *New York Times*.