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Don't buy a pig in a poke: Considering challenges of and problems with performance analysis technologies in Swedish men's elite football

Natalie Barker-Ruchti [a,*], Robert Svensson [a], Daniel Svensson [b], Dan Fransson [c]

[a] School of Health Sciences, Örebro University, Örebro, Sweden
[b] Department of Sport Sciences, Faculty of Education and Society, Malmö University, Malmö, Sweden
[c] Center of Health and Performance, Department of Food and Nutrition and Sport Science. University of Gothenburg, Gothenburg, Sweden

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ABSTRACT

During the last decades, technologies to monitor, test and analyze athletes' performance and health have rapidly developed. At present, global positioning systems (GPS), stadium camcorders, heart rate monitors and mobile applications are prominent performance analysis technologies (PATs) used in most elite sport environments. While PATs is understood as an aid, there is a growing body of literature that points to negative consequences. These negative consequences are concerning and call for research and measures to develop strategies for effective and productive implementation. To achieve this, this article first outlines key challenges and problems of PATs, using sport sociological research on coaching and athletes, historical knowledge of the scientization of training and the changing role of the coach, as well as scientific and experiential knowledge of performance analysis. Our findings show that key challenges and problems occur in a chain of six steps that concern the implementing of PATs: 1. Investment in PATs; 2. Production of performance data; 3. Interpretation of performance data; 4. Communication of performance data; 5. Decision-making based on performance data; and 6. Influence of PATs on coaches and athletes. The article then answers these challenges and problems by outlining recommendations for how sport managers and administrators can prevent buying "a pig in a poke" by acquiring competence about performance analysis and PATs, investing time, and developing effective communication between those working with PATs.

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* Corresponding author at: School of Health Sciences, Örebro University, 701 82 Örebro, Sweden.
E-mail address: Natalie.barker-ruchti@oru.se (N. Barker-Ruchti).
Twitter: @barkerruchti (N. Barker-Ruchti).

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1. Introduction

Performance analysis (PA) plays a key role in enhancing athletic performance. While coaches of the past relied on the naked eye to assess and train their athletes, today's many performance analysis technologies (PATs) significantly shape training practices and the sport coaching process (Carling, Wright, Nelson, & Bradley, 2014; Groom, Cushion, & Nelson, 2011; Mackenzie & Cushion, 2013; Nicholls, James, Bryant, & Wells, 2018; Rein & Memmert, 2016; Wright, Carling, & Collins, 2014; Wright, Atkins, & Jones, 2012; Wright, 2015). In economically strong sporting contexts such as football (soccer) in the UK and American football in the US, PATs are particularly integral. In such contexts, large teams consisting of various experts - assistant coaches, strength and conditioning coaches, player position-specific coaches, match and video/tactical analysts, and doctors, nutritionists, physiotherapists and psychologists - employ global positioning systems (GPS), wearable micro-technology sensors, video- and computer-assisted performance analysis, and mobile applications to generate data on physiological and kinematic parameters (e.g., distance covered in a match; number of and speed of acceleration), playing tactics, and health and wellbeing variables (e.g., anxiety; sleep; weight). Most of these measurements are produced on a daily and/or weekly basis and require elaborate and time-consuming specialist processing before they can be communicated to head coaches, sport managers and club directors, who in turn utilize the information to decide on and develop individual and group training tasks, player selection, and match play strategies.

Research on the impact of PATs on training and the coaching process, as well as coaches and athletes, indicates both positive and negative effects. PATs have been shown to enhance coaching effectiveness, the coach-athlete relationship, and athletes' safety and training behaviors (Butterworth, Turner, & Johnstone, 2012; Francis & Jones, 2014; Groom et al., 2011; Jones & Hemmestad, 2019; Wright et al., 2014). The literature outlining these positive effects, however, appears modest against the backdrop of the conceptual inconsistencies, methodological shortcomings, ethical concerns, inequalities, practical challenges, and problematic consequences that scholars have identified (Baerg, 2017; Carling et al., 2014; Groom et al., 2011; Kioussis, 2018; Kohe & Purdy, 2019; Luczak, Burch, Lewis, Chander, & Ball, 2020; Mackenzie & Cushion, 2013; Manley, Palmer, & Roderick, 2012; Williams & Manley, 2016; Wright et al., 2014). Due to the predicted exponential growth of PATs, these limitations and negative consequences are likely to increase and call for research and measures to develop strategies for effective and productive implementation (Luczak et al., 2020). Nicholls and colleagues' (2019) call for multi-disciplinary approaches appears particularly relevant to advance our understanding of PA and the effects that the use of PATs have on training and coaching, and coaches and athletes (Wright et al., 2012).

This paper aims to be an answer to this call. Co-authored by researchers in sport sociology, sport history and applied performance analysis, the overarching purpose of the paper is to provide sport managers and administrators aiming to, or working with PATs, with recommendations for the implementation of PATs. Specifically, our *first aim* is to outline challenges and problems that our collated expertise have shown to trouble PA. Based on this compilation of challenges and problems, our *second aim* is to develop recommendations for how sport managers and administrators may need to approach PA to avoid or at least manage the negative effects of PATs that existing research and experience has identified.

To achieve our two aims, we use Swedish men's elite football as a case study. Swedish men's elite football has recently started to invest in new forms of technologies, undoubtedly to adapt to the contemporary landscape of technology in this sport. Our observations are, however, that some investments in PATs are poorly informed and thus prone to result in the negative effects the existing literature has identified. We thus feel that collating the challenges and problems identified in research and providing recommendations for effective and productive implementation of PATs is useful and timely, both for professional football and elite-level team sport managers and administrators. Investing in (new) technologies is today an increasingly common practice (Claudino et al., 2019), and although we recognize that challenges and problems relating to PATs and their implementation are likely to differ between sports, as PATs and other technologies are developing quickly and its implications remain poorly understood, the questions we raise and the recommendations we develop have potential for sport settings beyond Swedish men's football. In what follows, we first sketch the research procedure we adopted for this paper and describe the current techno-situation in Swedish men's elite football. This will be followed by the main part of the article, the sociological, historical, and experiential knowledge on challenges and problems that trouble the implementation of PATs. The remaining two sections outline recommendations for effective and productive PA and summarize the contribution our research makes.

2. Research procedure and study context

The research conducted for this article followed an interdisciplinary research process (Hausken-Sutter, Pringle, Schubring, Grau, & Barker-Ruchti, 2021; Repko & Szostak, 2016). In such research, the two key research phases are to collate disciplinary knowledge to find 'common ground' and to integrate knowledge to construct more comprehensive understanding. To achieve these two outcomes, we conducted three scientific steps. First, each co-author drafted a text to represent their disciplinary expertise relating to PA knowledge in the elite sport context. Author 1 turned to sociological and coaching research to identify benefits, scientific limitations and problematic consequences of PATs; author 2 and author 3 turned to their historical research to explain the changing role of the Swedish men's elite soccer coach from the 1960s to 2010s, and the scientisation of endurance sport in Sweden since the 1930s respectively (Svensson, 2019; Svensson, 2018); and Fransson, 2018a; 2018b turned to his match analysis research and performance analyst experience in Swedish men's elite football clubs to determine the status quo of PATs and PA practices in Swedish men's elite football (Fransson et al., 2018a; 2018b). Through several meetings, we familiarized ourselves with our respective disciplinary and experiential knowledge and probed one another to understand how technological development and PATs have shaped, and continue to affect, the role of the coach, coaching and training practices, and athletes. Throughout these discussions, author 1 and author 4's coach education and author 4's applied PA experiences added contextual information on the current state of PATs in Swedish men's elite football. Second, and to create 'common ground' from the disciplinary expertise we each provided, we zoomed into the case of

Swedish men's elite football to identify challenges and problems the implementation of PATs create. As part of this step, we noticed that the challenges and problems related to different phases of investment in and implementation of PATs. Thus, we allocated the challenges and problems to a chain of six interrelated implementation steps: 1. Investment in PATs; 2. Production of performance data; 3. Interpretation of performance data; 4. Communication of performance data; 5. Decision-making based on performance data; and 6. Influence of PATs on coaches and athletes. Third, and lastly, to integrate the findings, we discussed how the challenges and problems identified in step 2 could be managed to avoid the negative effects that trouble PA. The implications we present in the conclusion represent the comprehensive understanding that interdisciplinary scholars argue such research can generate.

2.1. Current techno-situation in Swedish men's elite football

In men's elite football, it is the clubs of the big European leagues that have been leading the current PA landscape during the last decade. In Sweden, arguably due to a lack of economic resources, clubs have only in the past few years started to invest in PATs. The implementation has, however, been rapid and extensive. In just five years, the number of first division men's football teams employing GPS technology has increased from 2 to 11, out of 16 teams. Four of these clubs work today with more than one system and are implementing them with increasingly younger teams (e.g., U19 teams). Additional digital technologies, such as automated camera systems and mobile applications that produce data on well-being and nutrition, are also being purchased.

As a consequence of the implementation of new technology, we have observed that Swedish men's elite football clubs, as clubs elsewhere, have had to employ additional staff to assist the coach, such as sport scientists, tactical analysts, and other statistical analysts (for similar evidence in the UK, see Kohe & Purdy, 2019). This extension of coaching teams has also demanded new organizational roles and responsibilities. The term 'coach', for instance, has in many cases been replaced by 'manager', whose role has moved to managing a coaching team and making decisions based on the pre-interpreted information that expert personnel prepare based on the data the implemented PATs generate (Svensson, 2019). A further sign of the rapid change due to PATs is the boost Swedish sport science research has experienced in the past five years (Fransson et al., 2018a; 2018b; Sæterbakken et al., 2019). As a result of this research, separate undergraduate degree courses in training and match-analysis are now being offered. These courses are popular, mainly with those working in football organisations as sport scientists, fitness coaches, and amateur and professional coaches.

In sum, Swedish men's elite football PA practice is digitalizing fast. While this may benefit coaches and athletes, and performance, we also observe challenges and problems that we believe should and can be prevented. Below, following the six interrelated implementation steps outlined above, we demonstrate what they entail.

3. Challenges and problems while implementing PATs

3.1. Investment in PATs

Until the middle of the 20th Century, Sweden's football clubs did not (need to) invest in PATs, basically because technology was non-existing. Thereafter, PA on players' physical dimensions became outsourced, mainly because exercise science research had emerged, and the necessary technology was becoming available at the then Royal Central Institute of Gymnastics in Stockholm (Svensson, 2019; Svensson, 2017). Consequently, the laboratory at that institute became an 'obligatory passage point' for those aiming for a career in elite sports (Svensson & Sörlin & other, 2019). Gradually, particularly since the digitization of the 1990s, football organizations and clubs have begun to implement PATs themselves, on site. For example, in the early 2000s, the heart rate monitor was introduced as a tool to control and govern the players' individual internal workload during training (Svensson, 2019). The rapid increase of first division Swedish men's football teams employing GPS technology is another example.

However, the increased availability of PATs, often coupled with PAT companies' aggressive marketing strategies, does not only pressure football clubs to invest in such technology, it also requires those aiming to invest in PATs to have relevant knowledge to assess differences in product quality (Luczak et al., 2020). For instance, stakeholders must understand issues of validity and reliability as the measures GPS systems collect differ in accuracy because of different data chips, filters, and data-processing algorithms built into their hard- and software (Malone, Lovell, Varley, & Coutts, 2017). Validity and reliability is further affected by the number of satellites connected to the GPS unit during measurement (Witte & Wilson, 2004), real-time versus post session measurements (Aughey & Falloon, 2010), and minimum effort duration settings (Malone et al., 2017). Investors, as specialists and coaches, need to understand that the above-mentioned factors influence data collection and the quality of PAT data.

Challenges regarding relevant knowledge about PATs and problems regarding validity and reliability are particularly important against the backdrop of the limited budgets that Swedish (and arguably many other countries') elite men's football clubs have. Financial limitations are likely to require (re-)prioritization of money, which may disadvantage areas that also need to receive funding. In Sweden, a consequence may be that the financing of PATs in men's elite football will (further) disadvantage activities already receiving less funding (e.g., girls/women's and participation/non-elite football) (Ericsson & Horgby, 2020; Hjelm & Olofsson, 2003). Indeed, Baerg (2017) argues that PATs create a digital divide, which likely enhances existing inequalities between sporting contexts and nations. Pressure to invest in PATs remains high though, and may have particularly disadvantageous consequences, especially in present COVID-19 affected football club budgets.

3.2. Production of performance data

When PA was introduced in Swedish men's elite football during the 1960s and 1970s, exercise scientists produced performance data (Svensson, 2019; Peterson, 1989). While coaches did carry out some simple tests, the bulk of data collection was controlled by scientists, with athletes attending laboratories testing (Svensson, 2019; Svensson, 2017; Yttergren, 2012). On the one hand, this outsourcing of PA ensured the highest-level quality of research available at the time. On the other, as testing occurred in artificial settings, a major problem was that the tests could not provide real-life data. In addition, the scientific purpose at the time was not to enhance athletic performance, but to gain knowledge on how the body functions during extensive physical activity (Svensson, 2013; Schantz, 2015). In this sense, it was a potential and, in some cases, also actual conflict regarding the reason to produce data (Svensson, 2017; Day & Carpenter, 2015; Yttergren, 2012).

At present and as shown in the section on investment in PATs, the production of data is done on site, by club staff. While this solves some of the earlier problems faced because of testing taking place in laboratories, it has created new challenges. For instance, some scholars argue that PATs may only be able to measure what is measurable and not necessarily what is best for players' learning and performance (Mackenzie & Cushion, 2013; Wright et al., 2014). Further, research warns from a sole focus on variables that quantify and reduce the athlete to a dataset (Collins, Carson, &

Toner, 2016; Collins, Collins, & Carson, 2016; Kerr & Cooper, 2020; Williams & Manley, 2016). Quantifiable data may be informative and positively affect athlete health and training behavior, however, athletic success relies on many social (e.g., trusting relationship with coaches) and serendipitous factors (e.g., freak injury) that cannot be measured and quantified (Luczak et al., 2020). Lastly, with the implementation of PATs, additional experts have come to play integral roles in coaching teams (Nicholls et al., 2019; Wright, Carling, Lawlor, & Collins, 2016). Nicholls and et al.s' (2019) research has shown that analysts do not only implement PATs and produce PA data, they play a considerable role in influencing coaches. These relationships, and the power within them, play a central role in the interpretation and communication of data.

3.3. Interpretation of performance data

When physiologists first engaged with elite sports in Sweden in the 1950s, the general belief was that scientific measurements would easily transfer into coaches' decision-making. Elite cross-country skiers' oxygen uptake measured through bicycle ergometer testing was, for instance, assumed reliable to use for team selection (Åstrand, 1988). Such interpretation of data without paying attention to context is today considered inappropriate, especially given the ever-growing possibility to collect more detailed and sensitive data and the increasing demand to individualize training (Nicholls & Worsfold, 2016). Indeed, PA scholars agree that the quantification of training and performance should be contextualized in relation to, for instance, competitive season, match and play situations, referee decisions and importantly, player health and wellbeing (Mackenzie & Cushion, 2013; Wright et al., 2014). Further, an emerging challenge that scientists have raised is the production of longitudinal data, rather than snapshots of a given training session or match (Barnes, Archer, Hogg, Bush, & Bradley, 2014; Bush, Barnes, Archer, Hogg, & Bradley, 2015.

Lastly, a challenge could be that the influence of the specialist may be limited because of the different viewpoints coaches and specialists work from. Coaches tend to rely on experiential, often intuitive, knowledge (Collins, Carson et al., 2016; Collins, Collins et al., 2016); PAT specialists work from the premise of scientific data. As a consequence, coaches are likely to interpret statistical data using their experience and coaching philosophy (Ekstrand, Lundqvist, Davison, D'hooghe, & Pensgaard, 2019). While this interpretative step is necessary and makes sense, problems can occur if specialists lack understanding of the coaching process or the coaching philosophy of the coach they provide data for, especially if time constraints limit analysts' ability to pre-interpret data to make them 'consumable' for coaches (Kohe & Purdy, 2019; Luczak et al., 2020). Of course, the opposite also applies. The coaches' knowledge of PATs and PA data, or lack of, also influences interpretation. These risks pose challenging questions regarding effective and equal communication, including feedback timing, frequency and length, and the approach to deliver information.

3.4. Communication of performance data

Svensson (2019) has shown that as Swedish men's elite football clubs grew around the turn to the new millennium, and increasingly employed more assistant and specialist coaches, communication between the different levels, sections and expert personnel in the club organization became a problem. In short, previous communication systems, which were mostly between the head coach and the players, became inadequate for the large teams consisting of specialists producing various types of data through PATs. The large amount of data can indeed be a problem (Kohe & Purdy, 2019). For instance, the time necessary to test players and analyze data is extensive and has been found to negatively impact the time available to communicate with the players. Not knowing why data is collected and what it is used for can, however, detriment the coach-player and coach/player-expert relationships (Kohe & Purdy, 2019; Wright et al., 2014) and have a negative effect on motivation and meaning (Denison, 2007). This directs the focus to the infrastructure of communication within the clubs. Is there enough time and space for communication between specialists, coaches and players, and possibly managers? What should the communication of PA and PA data entail? When and how should the data be communicated?

On this note, Manley and Williams (2019) stress that the amount of data is not necessarily the problem. Rather, the challenge is data interpretation (as we have elaborated above) and communication between and across personnel and the players. Data may be produced and interpreted correctly, but if it is not communicated with a view to ensure health, well-being and performance, the effects may be organizational surveillance (Manley et al., 2012; Williams & Manley, 2016). Examples of such undesirable surveillance could be the collection of data during players' vacation and rehabilitation. While PAT mobility and digitisation allow this, the question of why becomes pertinent. Similarly, although we recognise that the monitoring of athletes is not a new phenomenon, contemporary PATs do produce ever more intrusive and personal data, a process that that can result in shame, destructive self-correction practices (e.g., restrictive diets; additional training practices; drug consumption), and health problems such as body dissatisfaction and eating disorders (Manley & Williams, 2019; McMahon & Barker-Ruchti, 2017; Williams & Manley, 2016). Certainly, PATs should not increase the already precarious position players may be in (Overbye, 2018).

The inappropriate use and communication of data directs focus to power relationships between PAT experts, coaches and managers, and experts/coaches/managers and athletes, and the communication necessary to avoid enhanced and detrimental disciplinary effects that research has identified (Manley & Williams, 2019). PAT specialists may be well equipped to validate and use different technology to monitor, test and analyze performance, however, if the transparency surrounding PA data is not provided, and data is used to control and manipulate players, undesirable consequences will have a myriad of detrimental effects. One is also to misinform coaches' decision-making.

3.5. Decision-making based on performance data

As illustrated above, a general belief in the past was that scientific measurements produced through, for instance, bicycle ergometer testing would easily transfer into coaches' decision-making (Åstrand, 1988). Indeed, Peterson (1993) showed how Swedish men's elite football coaches from the 1970s onwards selected their teams based on data from physiological tests. The declarative value of available data, however, is today understood not to provide guarantees and can in fact be wrong if interpretation, communication, and reception are compromised (Collins et al., 2012; Kerr & Cooper, 2020). Moreover, coaching literature demonstrates that intuition and 'gut feeling' are (still) important ways coaches inform their decisions (Herold et al., 2019; Luczak et al., 2020; Wright et al., 2014, 2016). A coach may, for instance, select a player for the next game even though data indicates that he/she is not recovered or is nursing pain or an injury (Jones & Denison, 2018; Jones, Marshall, & Denison, 2016). Similarly, a decision may be based on in-depth knowledge of how a player 'ticks best' even though PAT data indicates something else.

Our point here is not to argue that one never or only should base decisions on PAT data; it is about the negotiation between different types of data and different types of knowledge. It is crucial, for instance, that performance data is placed in context, such as players' current form, difficulty of fixtures played and referee decisions (Kohe & Purdy, 2019; Mackenzie & Cushion, 2013; Wright

et al., 2014). The need for negotiation also highlights the question of power within the coaching staff.

3.6. Influences of PAT on coaches and athletes

Historical research demonstrates how the influence of PATs on players has intensified over the years. The focus during the 1960s and 1970s was on players' physiology. Similar to what had already been the case for decades in endurance sports (Svensson, 2017; Svensson & Sörlin & other, 2019; Bourne, 2008), the idea that players are like machines with engines that coaches can test and tune, became increasingly popular in football. Gradually, the focus extended to include the players' tactics and mental status (Svensson, 2019). Today, the focus is on the individual player, producing data during training and competitions, and outside of sport on issues such as diet and sleep, a control that is today not only extensive, but problematic as research has shown. First, research indicates that athletes are concerned with how coaches use the data to determine selection and playing time, and to modify employment contracts (Williams & Manley, 2016). In Luczak et al.s' (2020) study, some athletes appeared to be reluctant to trust PATs and how their data were being handled. This reluctance is not new – it was evident already in the early stages of technoscientific performance analysis in sport when endurance athletes refused to hand over their training logs to physiologists or to subject themselves to scientific tests (Svensson, 2017; Svensson & Sörlin & other, 2019). Like today, arguments of personal integrity were provided as reasons for being reluctant to share data.

Second, recent literature points to the controlling and disciplinary effects that PATs have on athletes (Jones, 2019; Kohe & Purdy, 2019; Manley & Williams, 2019; Manley et al., 2012). Researchers' underlying critique is that although sport organizations and coaches consider the supervision of athletes necessary to ensure performance development, the extensive daily monitoring may be counter-productive to what training and coaching aims to achieve because it removes agency and creates 'socially empty' athletes (Denison, 2007; Williams & Manley, 2016). Scholars have demonstrated, for instance, that coaches who use performance data to threaten and coerce players to adapt social and training behaviors may shape athletes to become docile, a state known to increase self-criticism, ignorance of health concerns (e.g., continue to train/play despite injuries) and development of staleness towards training and competing (Jones et al., 2016; Markula, 2006). The research further demonstrates that these effects cause athletes to experience an increased sense of precarity, which may force them to compromise their health and thus harm performance.

Third, while PATs can be used explicitly and consciously to enforce disciplinary control, research has identified that some coaches are unaware of the disciplinary and controlling effects PATs have on athletes (Kohe & Purdy, 2019; Manley & Williams, 2019). They appear to be blinded by the assumption that PATs and the data they produce create a form of elevated intelligence that makes accessible previously untapped knowledge (Baerg, 2017). While PATs do of course produce knowledge in new (numerical) form, Collins et al. (2012) write that a danger of buying into the quantification of measurable variables is 'the illusion of scientific credibility and validity that provides a degree of authority to otherwise dubious ideas' (p. 184; see Luczak et al., 2020 for a similar argument). Indeed, the scientific allure of PATs have historically created a false sense of security that using technology is the best way to coach and train athletes (Howe, 2006; Rabinbach, 1990; Svensson & Sörlin, 2019), a trend that also applies to other technologies and society more broadly (Mavalankar, 1956). Unawareness of the influence PATs have on athletes also raises questions of privacy, especially in the age of GDPR. For instance, should data that is produced to enhance performance be repurposed to discipline athletes? Is it acceptable that athlete health is being determined based on measurable variables without athletes' subjective input? Is it ethical to share players' performance data with the public? According to Baerg (2017), the practices these questions refer to are ethically problematic because they do not ensure athlete agency, privacy, and anonymity. In a similar vein, Kioussis (2018) questions whether and how PATs can constitute a form of intellectual doping.

In sum, the six interrelated steps of the implementation chain as shown above illustrate the multitude of issues that those wanting to invest in PATs must consider. Considering and managing only one or a few of the steps is limited in ensuring effective implementation and use of PATs. All steps must be considered when planning to implement PATs. In the following last section of our article, we wish to outline three recommendations that we believe can support sport managers and administrators in deciding for, implementing, and generating effective outputs from PATs. The recommendations relate to competence, time, and communication.

4. Recommendations to stakeholders

Our first recommendation, *competence*, focuses on the knowledge that those sport clubs or organisations aiming to invest in PATs should acquire to prevent the detrimental effects that we have shown to have on the six steps of implementation. Svensson (2019) argues that as football clubs have grown in size, and the coaching staff have multiplied in numbers, it is important for club managements to reflect and make conscious decisions as to who should do what and what competence the different roles should have. On this note we recommend club managers and administrators, before investing in and implementing PATs, to make sure to have employed personnel with relevant knowledge and expertise (Martin, Swanton, Bradley, & McGrath, 2018). They should know the types of technology and what type of data they produce, and how to interpret and contextualize the information. Otherwise, investing in the emerging technologies will be "buying a pig in a poke".

Our second recommendation, *time*, focuses on the vast amounts of time that PA using PATs demands from specialists, coaches and athletes, and possibly managers and administrators. Staff may be very competent in implementing PA and PATs, but if time is limited, their ability to make effective use of their competence will be compromised. Making ample time available for performance analysts to communicate with relevant stakeholders is particularly important. We believe that by prioritizing effective communication, several of the problems that we have outlined above can be minimized or even prevented. For example, if coaches and analysts have time to communicate to athletes why data is collected, how it is interpreted and affects decisions, a buy-in can be created and they are likely to become less docile. Further, time is also needed for coaches, specialists, and analysts to discuss what the different types of data mean and what long- and short-term effects they can and should have. Thus, an effective coach-analyst relationship whereby both can and have ample time to contribute their views and knowledge within an open environment is important. Put another way, as possibilities to gather data using PATs increase, so does the amount of time necessary to process the data. If time is constrained, then sport managers, administrators, specialists and coaches should carefully consider if investment in new or additional PATs makes sense.

Our third recommendation, *communication*, focuses on the process of PA and the relationships between the stakeholders working with and affected by PATs (i.e., specialists; coaches; athletes; managers; other support staff). As with time, staff may be competent in PA and PATS, and have ample time, but if they cannot develop effective communication systems and practices, their knowledge and input may not be implemented as required or with the desired effects. Groom et al.'s (2011) write that PA is presently depicted

through 'simplistic flow charts and schemas; often illustrated with an unproblematic shift from performance, observation, planning, training and practice' (p. 17). The above chain of implementation steps has shown, however, that the PA process using PATs goes beyond such existing models to include prioritization of finances for PA and influence on coaches and athletes. While research is limited regarding the broader contextualization of PA and PATs, what can be said regarding communication is that all involved actors (e.g., manager; coach; PAT experts; players) should share a 'mental model' that aligns the value of and beliefs in PA and PATs (Wright et al., 2014). If clearly communicated, the model should build trust between the actors that share the mental model (Groom et al., 2011).

Our reference to PATs' disciplining effects on players demonstrates the importance of a shared model. Communication of negatively perceived values such as weight gain and skinfold measures deemed higher than a given standard, especially if made in public, has been shown to have far reaching counter-productive consequences, including decreased health and well-being, and motivation to train (Jones, 2019; Manley & Williams, 2019; Williams & Manley, 2016). Thus, football managers, coaches and PAT experts must carefully consider what, how and when they should communicate with players. Communicating the purpose of PATs and PAT data, as well as involving athletes in discussing how PA and data should be used to determine their training is an important strategy to prevent manipulative communication, manager/coach control, and athlete docility (Williams & Manley, 2016). This can reduce frustrations with and fatigue of PAT data and offer opportunities to actively participate in decisions that affect players and facilitate personal and athletic growing. In this regard, we recommend that individually tailored PA that is based on detailed knowledge of players' needs and preferences, like humanistic and athlete-centered coaching principles, offers important potential to prevent the blanket surveillance approach that has been evidenced by the majority of existing critical sociological and PA literature (Carling et al., 2014; Groom et al., 2011; Williams & Manley, 2016; Wright et al., 2014). In terms of communication, as competence and time, such an approach is not without challenges and can be demanding. However, to maximize the use of PATs, we see the individual approach necessary.

In sum, our recommendations relating to competence, time and communication demonstrate their interrelatedness. Without time, a player-centered approach to PA is unlikely to be fruitful. Without the right competence, time or a player-centered approach are futile if unreliable PAT data is being produced. Thus, we propose that competence, time, and communication do not only require careful deliberation, but the recommendations must also be implemented in their entirety to prevent the detrimental effects documented in sociological literature.

5. Conclusion

In the article, we have aimed to outline key challenges and problems with PATs, using historical, sociological and experiential knowledge of PA and PATs, and to outline recommendations as to what sport managers and administrators may need to consider in order to avoid or at least manage the challenges and problems identified. Using a chain of six implementation steps, we have demonstrated what each of the steps entailed historically and what they involve in today's context of PA and PATs. To ensure effective implementation and prevent the detrimental effects documented in existing literature, we recommend that knowledge about PATs, extensive time to implement PATs and make effective use of PAT data, and productive communication between different actors, must be put in place for investments in PATs to be worthwhile.

In terms of continued scholarship, and as others have proposed (Wright et al., 2014), we recommend that further applied and/or case-based research be conducted to provide real-life insight into the implementation, use, and effects of PATs. Certainly, such research is called for in Sweden as at present, such scholarship is limited to historical analyses. Lastly, we see a specific need in developing coach and sport management education that incorporates the six steps we have included in the chain of PA and PAT implementation (see Martin et al., 2018 for a similar argument). In Sweden, this need is particularly pertinent as coach education is limited by compartmentalized PA/PAT and pedagogy/sociology courses. Coach education that integrates the technical aspects of PA and PATs, critical knowledge on PA and PATs as we have presented in this article, and the issues of competence, time and communication would in our view go a long way to prevent the negative consequences research has documented. The same goes for sport management education, as it is a management issue to provide for relevant competence, time, and communication within sport clubs.

CRediT authorship contribution statement

Natalie Barker-Ruchti, **Robert Svensson, Daniel Svensson and Dan Fransson**: contributed to the collation of data, writing the manuscript. **Natalie Barker-Ruchti**: conceptualised the research area.

Declaration of Competing Interest

The authors of the manuscript 'Don't buy a pig in a poke: Considering challenges of and problems with performance analysis technologies in Swedish men's elite football' have no conflict of interest to report.

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