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ORIGINAL ARTICLE

Genetic Testing in Professional Football: Perspectives of Key Stakeholders

Alexander B. T. McAuley[1,5] · David C. Hughes[1] · Loukia G. Tsaprouni[1] · Ian Varley[2] · Bruce Suraci[3] · Thomas R. Roos[4] · Adam J. Herbert[1] · Adam L. Kelly[1]

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Abstract

Purpose Genetic research in football is currently in it's infancy but is growing rapidly. However, the practical application of genetic testing in football and the views concerning its use are unknown. Thus, the purpose of this study was to assess the current practical application of genetic testing in professional football and provide an insight into the perspectives of key stakeholders (i.e., coaches, practitioners, players).

Methods In total, 122 participants completed an online anonymous survey. This consisted of 21 multiple choice and Likert scale questions, with the option of providing an explanation for each response.

Results Findings revealed genetic testing is rarely utilised by key stakeholders (10%) or their respective organisations (14%). However, three quarters (75%) had the opinion that genetic testing will have great utility in the future. The majority (72%) believed genetic testing should be used for athlete development and injury risk, whilst 35% believed that genetic testing should be utilised for talent identification purposes. However, most key stakeholders viewed their own (89%) and their colleagues' (79%) knowledge related to genetic testing as insufficient; mainly due to ineffective current communication methods (91%). Most believed educational workshops are required (71%), whilst nearly all (91%) were interested in developing their expertise on the utility of genetic testing.

Conclusion Genetic testing is rarely used within professional football, although key stakeholders anticipate that it will be utilised more in the future. As such, educational support may prove valuable in improving key stakeholder knowledge and the practical application of genetic testing in professional football.

Keywords Soccer · Talent identification · Athlete development · Genetics

Introduction

Achieving elite status in professional sport is a multifactorial process [15]. More specifically, task constraints (e.g., deliberate practice,deliberate play), performer constraints (e.g., psychological characteristics; physiological factors), environmental constraints (e.g., relative age effects; birth place effects), and genetic factors have previously been shown to interact to facilitate sporting success at adulthood [6, 27]. To what extent each of these facets influences performance specifically in football remains unclear [28]. Current research has estimated that the genetic contribution (i.e., heritability) to overall athletic status is ~ 66% [7], with the estimated genetic influence on specific performance traits ranging broadly from 30% to 80% [37]. Moreover, several genetic markers have been identified that may be associated with athlete status and specific performance-related phenotypes

✉ Alexander B. T. McAuley
Alex.Mcauley@mail.bcu.ac.uk

1 Faculty of Health, Education and Life Sciences, Birmingham City University, Birmingham, West Midlands, UK

2 Department of Sport Science, Nottingham Trent University, Nottingham, UK

3 Academy Coaching Department, AFC Bournemouth, Bournemouth, UK

4 The International Academy of Sports Science and Technology (AISTS), University of Lausanne, Lausanne, Switzerland

5 Department of Life Sciences, Birmingham City University, City South Campus, Westbourne Road, Edgbaston, Birmingham B15 3TN, UK

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in football, such as the alpha-actinin-3 (*ACTN3*) R577X and angiotensin-I-converting enzyme (*ACE*) I/D polymorphisms (see [17] for a review).

In light of this potential for genetic variation to influence performance, both direct-to-consumer (DTC) and provider based genetic testing services are now offered by many companies [35]. Several DTC companies specifically target professional sport with advertising campaigns, which claim to provide personalised training and nutritional information to optimise performance and reduce injury susceptibility based on an athlete's genotype [10]. Despite genetic testing in sport being a relatively new field, several athletes, practitioners, and organisations at the professional level have begun to embrace genetic testing as part of their training regime [11]. Indeed, genetic testing related to sport performance and injury susceptibility has been utilised within several sports in the UK [33]. Furthermore, genetic testing in sport has been used in a variety of circumstances throughout the world, such as identifying age, verifying gender, detecting doping, and revealing medical conditions [23].

Interestingly, there is anecdotal evidence in football that suggests genetic testing is being used to identify and select talented performers [29]. This is concerning for many researchers and practitioners, not only because the existing evidence which DTC companies base their recommendations on is limited [30], but also due to the accompanying social, ethical, and legal issues associated with potential genetic discrimination [10]. As such, several scientific consensus statements have deemed that the utilisation of genetic information, particularly for predicting future performance, is inappropriate and without scientific creditability [34, 35]. However, as genetic testing in sport is still in its infancy, there is currently limited formal regulation and legal legislation [23]. As a result, organisations within football currently have little guidance on best practices, which may result in key stakeholders (i.e., coaches, practitioners, players) becoming vulnerable to misinformation [30].

Despite anecdotal evidence, it is not yet known the extent to which genetic testing is taking place in football and why key stakeholders may or may not use genetic testing. To the authors' knowledge, there are only two peer-reviewed studies that have assessed the current use and opinions of genetic testing in sport [25, 33]. However, these studies only included 23 and 22 stakeholders employed in football respectively, limiting the application of their results to a football-specific context. As such, the aim of this study was to assess the current practical application of genetic testing in professional football by providing an insight into the perspectives of key stakeholders.

Methodology

Recruitment

Key stakeholders employed in professional football were contacted via email and by word of mouth from pre-existing personal and professional contacts. They were each invited to participate in this current study by completing the online anonymous survey and distribute it to other relevant parties. The study was also posted and advertised on various social media platforms. Invitations and posts included a link to the survey, whereby upon clicking the link, individuals would be subsequently directed to: (a) an information sheet detailing the survey's purpose and eligibility requirements, and (b) an informed-consent form. The inclusion criteria consisted of: (a) being aged at least 18 years, (b) employed as a member of staff at a professional football club or organisation involving player development or contracted as a current player, and (c) providing informed consent. Ethical approval was granted by the corresponding author's institutional ethics committee.

Survey

The survey was completed anonymously utilising an online survey tool (https://www.onlinesurveys.ac.uk), which is fully compliant with UK Data Protection laws and meets UK accessibility requirements. The survey comprised of 21 multiple choice and Likert scale questions regarding genetic association research and genetic testing in sport (see Supplementary File 1 for survey template). Respondents were also offered the opportunity to provide a qualitative explanation for their answers to enrich the quantitative data collected from the questions. Indeed, mixed-methodologies are encouraged in contemporary sport science research to ensure that findings are grounded in participants' real-life experiences [14]. The questions were broadly separated into the following six themes: (a) demographics, (b) utilisation, (c) awareness, (d) impact, (e) implementation, and (f) education. Data analysis consisted of frequency-based descriptive analysis, which was provided by the survey software directly, then exported for confirmation and further analysis. Methodological procedures are in accordance with Varley et al. [33] and Pickering and Kiely [25].

Results

Demographics

In total, 122 key stakeholders completed the survey between July 13th, 2020 and September 4th, 2020. The key stakeholders were predominately male (90%) and aged between 25 and 34 years (48%). Their specific employment roles included: Coach (*n* = 40), Player (*n* = 24), Physiotherapist (*n* = 16), Sport Scientist (*n* = 16), Strength and Conditioning Coach (*n* = 9), Performance Analyst (*n* = 5), and Nutritionist (*n* = 2). The remaining 10 stakeholders specified their employment role as "Other", which included: Football Consultant, Football Administrator, Hospitality and Sponsorship Manager, Manager, Operations Manager, Operations Manager of Charitable Projects, Performance Lead, Player Recruitment, Sponsorship Development and Management, and Sport Psychologist. There was a relatively even distribution between those working in Youth/Academy (52%) and Senior (48%) football (Fig. 1). The key stakeholders represented a wide spectrum of competitive playing standards at each level (e.g., Youth/Academy: International [*n* = 4], Academy Categories 1–4 [*n* = 45], and Non-Academy [*n* = 6]; Senior: International [*n* = 6], Divisions 1–4 [*n* = 32], and Non-League [*n* = 17]).

Utilisation

A small minority of respondents reported that they have used genetic testing to aid performance (9%) and/or mitigate injury risk (10%). Similarly, a slightly larger proportion of respondents recounted that an organisation they were employed at has used genetic testing to aid performance (15%) and/or mitigate injury risk (12%). However, the large majority of respondents suggested that they would consider utilising genetic testing in the future for both aiding performance (83%) and/or mitigating injury risk (84%) (**Fig. 2a**). Explanations for selections were provided by some respondents. For example:

> "Pretty uncertain how will genetic tests give additional knowledge to what current performance/medical tests can give. The relationship between genetics, epigenetics, and environmental factors is too complex and poorly understood at the moment. It seems they are deeply interrelated and probably best understood on whole system level. However, maybe advances in our knowledge may make me change my opinion" (Coach, aged 25–34 years).

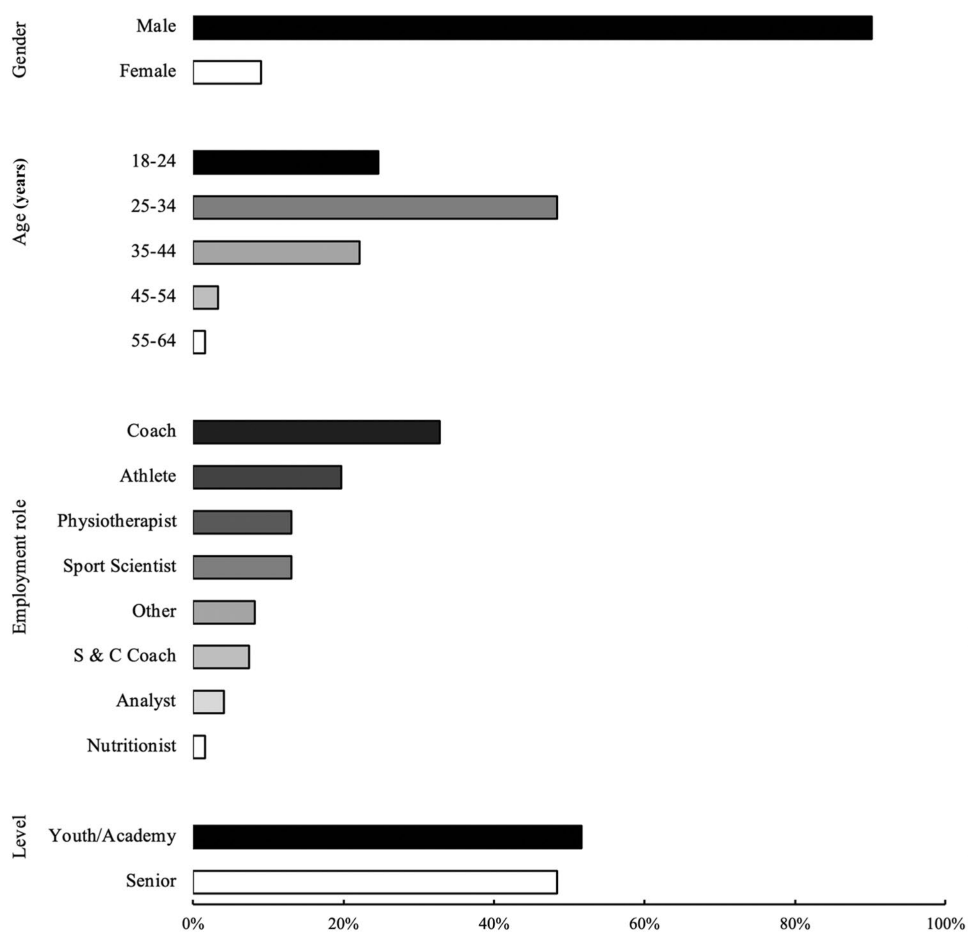

Fig. 1 Demographics of key stakeholders

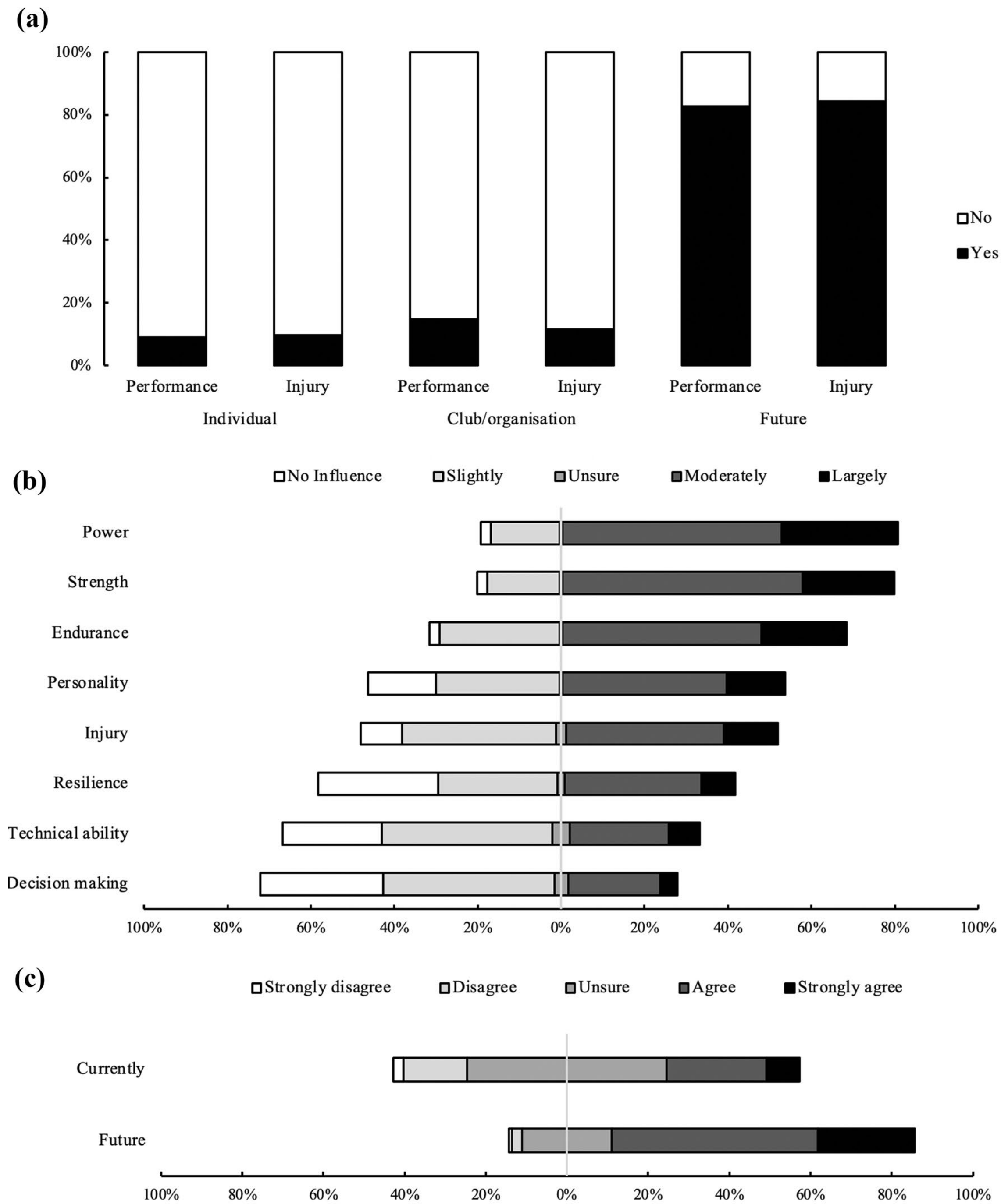

Fig. 2 Selection percentages of key stakeholders concerning: **a** utilisation; **b** awareness; **c** impact

Awareness

Overall, power was viewed as the most genetically influenced trait, as it amassed the most 'largely' selections (28%), along with the largest combined 'moderately' and 'largely' selection percentage (81%). In contrast, decision-making was viewed as the least genetically influenced trait, as it amassed the most 'no influence' selections (30%), and similarly the largest combined 'slightly' and 'no influence' selection percentage (71%) (Fig. 2b). There was a clear pattern in the data showcasing that the majority of key stakeholders perceive genetics to be less influential on psychological-related traits (i.e., decision-making, technical ability, resilience), and more influential on physiological-related traits (i.e., power, strength, endurance). Explanations for selections were provided by some respondents. For example:

> "Strength and power capabilities from what I have experienced always seem to be the most difficult to make significant and meaningful gains. Some players appear to make greater improvements doing similar or sometimes even less work than others. I typically see this is as a genetic advantage. The other categories in my experience can be more heavily influenced by environmental factors, the athlete's upbringing and training history" (Strength and Conditioning Coach, aged 25–34 years).
> "Physical attributes can be bettered through training, but the baseline is dependent on genetics. Decision making is affected by experience and knowledge, which can only be learned. I believe nurture rules over nature for personality" (Performance Analyst, aged 25–34 years).
> "I believe technical ability, decision making, resilience and personality are learnt practises whereas I believe most of the others can be influenced by genetics to some degree" (Athlete, aged 18–24 years).

Impact

Overall, the opinion of key stakeholders regarding the current utility of genetic testing in sport varied considerably, with 49% unsure, 33% agree/strongly agree, and 18% disagree/strongly disagree. However, the majority agree/strongly agree (75%) that in the future genetic testing will have great utility (Fig. 2c). Explanations for selections were provided by some respondents. For example:

> "Currently an emerging area of research (relatively speaking) in the field of sport science. Not fully understood in health/medical fields yet, so much more research required before application can be considered" (Nutritionist, aged 35–44 years).
> "Too little is known at the moment regarding the influence of genetics in sport, the work (and sample sizes) are way below anything known in disease" (Sport Scientist, aged 35–44 years).
> "Genetics plays a small role in performance. Data on genetic factors can contribute towards overall analysis on a players' performance" (Coach, aged 18–24 years).

Implementation

How

Overall, the opinion of key stakeholders regarding the use of genetic testing for talent identification/selection is unclear, as selections were almost evenly distributed: disagree/strongly disagree (36%), agree/strongly agree (35%), and unsure (29%). However, for athlete development/training and injury risk/prevention, the majority of respondents support genetic testing (agree/strongly agree = 70%; 74%) (Fig. 3a). Explanations for selections were provided by some respondents. For example:

> "I feel it is unethical to select a player based on their genetic potential or ability, they should be identified or selected on merit. When they're in the system genetic testing should then be used to optimise their potential" (Strength and Conditioning Coach, aged 25–34 years).
> "I think it would definitely help in talent identification and picking players for certain sports and positions in respective sports. This is already done especially in America where the majority of sports science research comes due to the level of funding" (Physiotherapist, aged 18–24 years).
> "Research (that I'm aware of/read) the focus is on injury risk/prevention and would help provide an insight (by no means the only factor) into a risk that could be mitigated by adapted training, nutrition etc" (Nutritionist, aged 35–44 years).

Barriers

Overall, cost (64%) and knowledge/inability to interpret results (51%), amassed the most 'largely' and only selection majorities. Whereas, the largest combined 'moderately' and 'largely' selection percentages were: (a) cost (83%), (b) knowledge/inability to interpret results (81%), (c) time (68%), and (d) ethical issues (53%) (Fig. 3b). Explanations for selections were provided by some respondents. For example:

> "For bigger clubs who have the money and time for long term results it would be beneficial, but for smaller clubs that need short term success to even just stay afloat then it wouldn't be an option. A lot of management are stuck in tradition and recruit players on their/coaches opinion and don't rely on data to tell them" (Performance Analyst, aged 25–34 years).
> "Knowledge and inability to interpret results have the biggest impact. If we are sure they will help, someone will do it to gain an advantage. I am also not sure that any future knowledge and ability to interpret results will help. There is a probability they just present limited, non-contextual information" (Coach, aged 25–34 years).

Payment

Overall, the majority of respondents expected the pay between £1–100 for a genetic test (71%) and education/

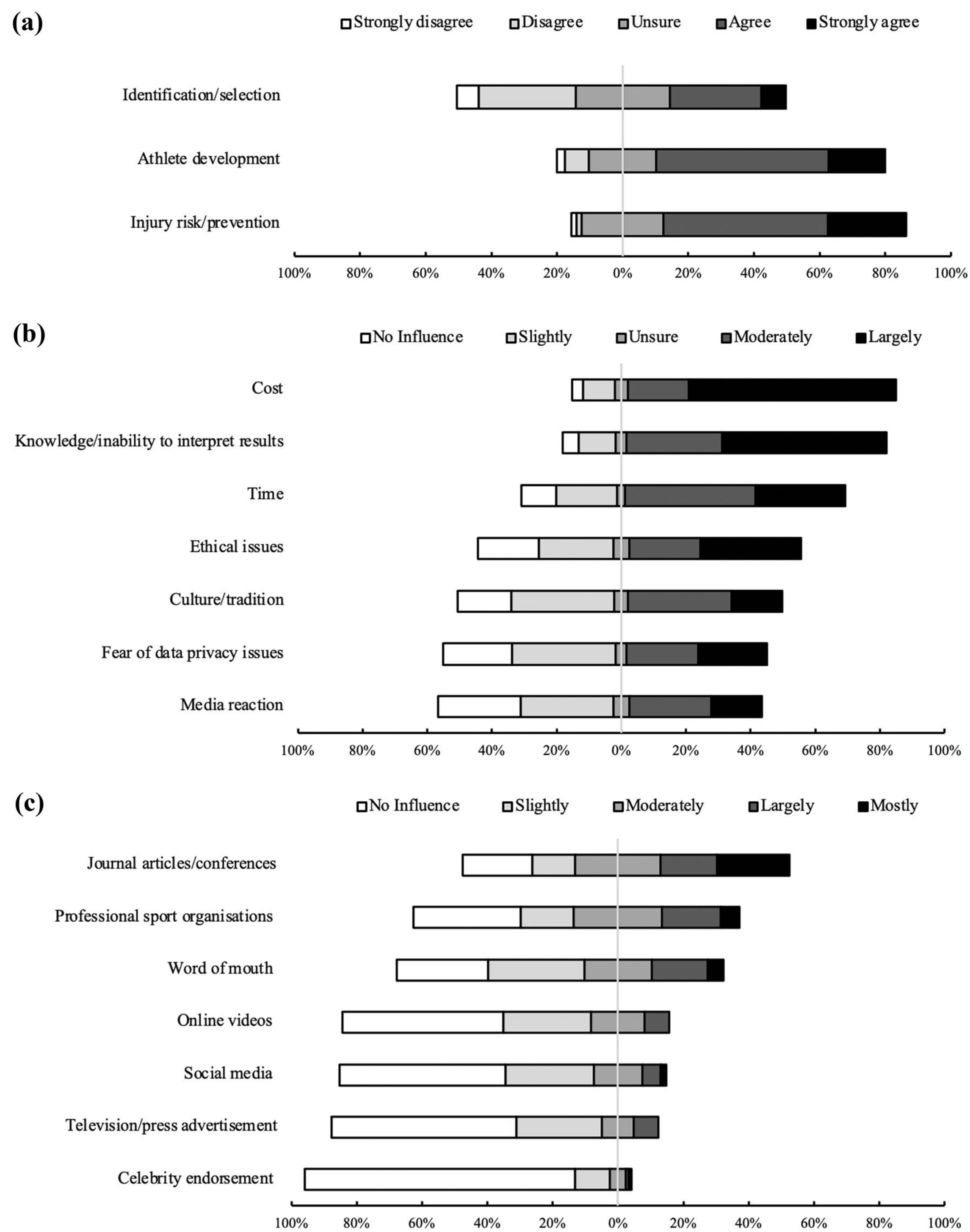

Fig. 3 Selection percentages of key stakeholders concerning implementation. **a** How; **b** barriers; **c** influence

training (76%), with the largest selections being £76–100 (25%) and £26–50 (29%), respectively. Whereas, the majority of respondents expected to pay between £26–100 for a consultancy to analyse and interpret results (67%) and genetic counselling to explain results (69%), with the largest selections being £76–100 (26%) and £26–75 (48%), respectively.

Access

Regarding who should be allowed access to an athletes genetic data, the respondents selected the following: athlete (24%), scientific staff (19%), parents (14%), anyone athlete consents (14%), sports club (14%), genetic testing company (11%), national government (2%), and sports league/association (2%). Explanations for selections were provided by some respondents. For example:

> "I think it should be whoever the athletes consent and the club doctors. The information should belong to the athlete and should be subject to data protection" (Performance Analyst, aged 25–34 years).
> "I think the athlete and the professional club should have access as long as the athlete is an adult i.e. 16 and above" (Coach, aged 35–44 years).
> "Scientific staff < Medical staff. Perhaps player or guardian would need to sign waiver agreeing to results being accessible to club medical staff at the very least" (Sport Scientist, aged 25–34 years).

Influence

Regarding to what extent specific information sources influenced the respondent's opinions, scientific journal articles/conferences amassed the greatest number of 'mostly' selections (22%), along with the largest combined 'mostly' and 'largely' selection percentage (39%). This was followed by professional sport organisations (24%) and word of mouth (22%). In contrast, celebrity endorsement amassed the greatest number of 'no influence' selections (83%), along with the largest combined 'no influence' and 'slightly' selection percentage (94%). This was followed by television/press advertisement (83%), social media (78%), and online videos (76%) (Fig. 3c).

Education

The overwhelming majority of respondents indicated that their own individual knowledge (89%), along with their colleague's (79%) of genetic research/testing is insufficient. In addition, the overwhelming majority (91%) believed genetic research is not communicated effectively to key stakeholders. Furthermore, the overwhelming majority indicated that they would be interested in learning more about genetic research in sport (89%), a large number believed that educational workshops are required at their organisation (71%), and a minority believed that the regular opportunity to speak to a genetic specialist or addition of a genetic consultant was required at their organisation (49%). Explanations for selections were provided by some respondents. For example:

> "Specialist subject area—although I aim to actively read relevant genetic research by no means do I consider myself qualified enough in this area, would require some consultation with appropriate professionals" (Nutritionist, aged 35–44 years).
> "Have BSc in Molecular Biology, but do not feel comfortable to make such decisions" (Coach, aged 25–34 years).

Discussion

The purpose of this study was to assess the practical application of genetic testing in professional football by providing an insight into the perspectives of key stakeholders. To the authors' knowledge this is the first study to quantify the use and opinions of genetic testing from a wide range of key stakeholders specifically in football.

Key findings suggest that, although genetic testing is utilised within professional football, it remains relatively rare. Interestingly, genetic testing may currently be used by organisations more frequently compared to four years ago. For example, Varley and colleagues [33] reported that only 2% and 5% of their multi-sport respondents were aware of their organisations having ever utilised genetic testing for performance or injury, respectively. In comparison, our current study revealed 15% and 12% of respondents were aware that their organisation had utilised genetic testing for performance and injury, respectively. This coincides with the recent findings of Pickering and Kiely [25], as 11% of their respondents reported that their organisations have utilised genetic testing. This cumulative 10% increase could be due to a number of possible factors. First, this may represent an increased interest in genetic testing in sport, corresponding with the increase in sport genomic research in recent years [30]. More specifically in football, McAuley and colleagues [17] showed that 55% of genetic association studies involving football players have been published within the last 4 years. Second, this increased proportion could also illustrate a more accurate representation of the true, and larger, prevalence of genetic testing within professional football. This would not be surprising, as the superior financial situation of football compared to most other sports, especially in Europe [22], would allow key stakeholders in football to afford a wider spectrum of potential performance measuring metrics. Finally, this increase could just simply be the result of genetic testing becoming more economically viable [35]. For instance, the cost of whole-genome sequencing now costs less than $1,000 compared to over $10,000 in 2010 [21]. Furthermore, the recent surge of DTC companies has inevitably made genetic testing more accessible. Overall, it is most likely a combination of these factors. This is due to significant advances in genomic technologies coupled with rapid reductions in cost outpacing Moore's law [10].

If key stakeholders in professional football were to use genetic testing, this study suggests they would mainly do so for physiological-related traits. For instance, the respondents in this cohort believed that genetics have a moderate to large influence on physiological traits, whereas they believed they have a very minor influence on psychological traits. This may be explained by the paucity of genetic research on psychological traits in football. Indeed, a recent systematic review showcased that out of 80 genetic association studies involving football players, only three studies investigated psychological traits compared to 20 on physiological traits [17]. As such, in football, there is currently a limited psychogenetic evidence base available to key stakeholders to form their opinions on genetic associations with psychological traits. However, it is important to consider that contemporary genetic studies in sport indicate that all traits, irrespective of physiological or psychological foundation, are moderately to highly hereditary [9]. Indeed, the most comprehensive heritability meta-analysis to date (including ~ 14 million twin pairs and 17,804 human traits) reported a weighted heritability estimate across all human traits of 49% [26]. Although, as genetic testing aims to reveal which variants (previously associated with specific traits) an individual possesses, it should be noted that very few psychogenetic variants have been identified and validated in sport [32]. In light of this information, perhaps the perspectives of the key stakeholders should not be surprising regarding the genetic influence on psychological traits.

This study suggests that there is limited knowledge of genetic research and/or testing amongst key stakeholders in professional football. For instance, almost half of the stakeholders (49%) in this study reported that they are unsure of genetic testing's present utility. Moreover, the majority (81%) reported their inability to interpret results as a significant barrier to implementing genetic testing in football. This is exemplified by most of the stakeholders (84%), who believed that no employee at their organisation has sufficient knowledge of genetic research and testing. This may be due to the education methods accessible to stakeholders at football organisations, as an overwhelming majority of stakeholders (91%) indicated that genetic research is not currently communicated effectively with coaches, practitioners, and players. This is potentially problematic, especially when it is anticipated that genetic testing will become increasingly common, which is reinforced by most stakeholders (75%) who believed genetic testing will have great utility in the future. For instance, it has been reported that China are implementing genetic testing as part of their athlete selection ahead of the 2022 Winter Olympic Games [12]. Indeed, a number of football organisations, such as FC Barcelona [20] and the Egyptian Football Association [13], have recently begun to utilise genetic information for training optimisation and injury prevention. Thus, more effective education may be needed in football. This was also indicated by a large proportion of stakeholders (71%) in this current study, who reported that educational workshops are required at their organisations. It could be suggested, the implementation of an education programme on genetics may be well received in football, as nearly all of the stakeholders (91%) expressed a desire to learn more about genetic research and the validity of genetic testing. As such, future research is required to explore the most efficient and effective approaches to provide evidence-based information on genetic research and practical application in professional football.

Education may be particularly important for key stakeholders in professional football when considering uses of genetic testing. Specifically, although the majority of stakeholders (72%) believed genetic testing should be used for athlete development and/or injury risk, over a third (35%) believed genetic testing should also be utilised for talent identification and selection purposes. This may be considered problematic, as the use of genetic testing for talent identification and selection in sport is currently considered immoral, unethical, and unlikely to give useful information [23, 34, 35]. Indeed, using genetic testing for these purposes could impede child development and constrain their right to an open future [5]. It is also important to consider that genetic research into athlete status has yielded few genetic variants that have been adequately replicated in independent cohorts [1]. This is due to their small effect sizes and consequent lack of explained inter-individual variance between athletes and controls [4]. For example, a recent review meta-analysed the most studied genetic variants associated with athlete status in football (i.e., *ACTN3* R577X and *ACE* I/D), which reported only modest allelic odds ratios of 1.18–1.35 [18]. In the future, it is also highly unlikely any genetic variant, or polygenic profile, will ever have the specificity/sensitivity to solely predict future sporting prowess [24, 36]. Indeed, currently only 24.6% of height, which has an estimated heritability of 80%, has been explained by genome-wide significant polymorphisms [38]. This is underpinned by the complexity of gene–gene and gene-environment interactions, as well as the multifactorial and dynamic nature of athlete development [3, 19, 31, 37]. Therefore, as high-performance is not an isolated, independent, or static trait, expertise in the sporting domain may never be fully quantifiable or predicted accurately via any performance measuring metric, including genetic information [8, 16]. As a result, key stakeholders in professional football are recommended to act with caution when utilising genetic testing for these purposes, whilst researchers are encouraged to design, implement, and evaluate methods of education.

Limitations

Although this study has amassed the opinions from coaches, practitioners, and players across a wide-range of competitive playing levels in youth and senior football, it should be acknowledged that it is not without its limitations. Specifically, the sample size was relatively small, the majority of respondents were male, and the views expressed are not representative of the entire football ecosystem (e.g., no responses from medical doctors). Previous research has also demonstrated that there are gender, age, educational, and social/cultural related differences in the acceptance of genetic testing [2], which may have influenced the results based on our cohort demographics. Moreover, economic differences between countries and organisations may have influenced the results as the authors' pre-existing contacts were predominately U.K based. Since the survey was anonymous, sampling bias may also have skewed responses as it is unknown how many key stakeholders were from the same organisation. Furthermore, as the survey was circulated on social media, this may have biased the sample as the authors' followers may be interested in genetic testing. Finally, the questions within the survey were not validated, but did comprise of similar questions to Varley et al. [33] and Pickering and Kiely [25] to allow comparisons. Moving forward, it is important that future research considers the use of a validated survey to capture more consistent datasets. Nevertheless, the collected responses provide a useful preliminary assessment of the existing knowledge and application of genetic testing in professional football from a diverse cohort of key stakeholders.

Conclusion

This study suggests that genetic testing is rarely used within professional football. However, key stakeholders anticipate that it will be utilised more in the future. Given the perceived lack of knowledge and education, implementation of education programmes may prove valuable in improving key stakeholders' knowledge and the practical application of genetic testing in professional football. Further studies using larger and/or diverse cohorts are encouraged in order to determine and validate the perspectives of key stakeholders. In addition, future studies should explore what methods are most effective in providing key stakeholders with evidenced-based information on genetic research and testing. Ultimately, it will be essential that future research critically examines the practical application of genetic testing within professional football.

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Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

Ethics Approval Ethical approval was granted by Birmingham City University via the Health, Education, and Life Sciences Academic Ethics Committee.

Consent to Participant Informed consent was obtained from all individual participants included in the study.

Consent to Publish Informed consent was obtained from all individual participants included in the study.

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