Does physical characteristics play a role when selecting youth soccer players into a development program?

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ABBREVIATIONS

In order of appearance

HIR	High intensity running
COD	Change of direction
KM	Kilometres
KM/H	Kilometres per hour
UEFA	Union of European Football Association
FIFA	Fédération Internationale de Football Association
EPL	English Premier League
M/S	Meters per second
CMJ	Countermovement jump
NFF	The Norwegian Football Federation
ICC	Intraclass correlation coefficients
1RM	One repetition maximum
KG	Kilograms
SD	Standard deviation
CI	Confidence interval
ES	Effect size
P_{max}	Maximal power

ABSTRACT:

BACKGROUND: Soccer is a complex sport that require scouts and coaches to assess a number of physical characteristics when selecting players to developmental systems. The aim of this study was to compare physiological test performance characteristics of players selected into a Norwegian talent developing program (selected) with their equal peers (non-selected).

METHODS: Ninety-six soccer players divided into groups of selected and non-selected (selected girls: n = 14, mean age 14.8 ± 0.2 years; non-selected girls: n =18, mean age 15.5 ± 0.6 years; selected boys: n = 16, mean age 14.7 ± 0.3 years; non-selected boys: n = 48, mean age 14.7 ± 0.3 years) were tested for 10-, 20-, 30-m linear sprint, velocity m/s, change of direction (COD) dominant and non-dominant, and countermovement jump (CMJ) in an indoor laboratory.

RESULTS: Independent t-test and Cohen's effect sizes (ES) were used to compare means. Group comparisons revealed trivial to large ES for 10-, 20-, 30-m sprint, velocity, CMJ, and COD dominant, and non-dominant were (0.15; -0.42; -0.35; 0.06; -0.57; -0.64; -0.43), respectively, for girls and (-0.93; -0,80; -1.04; 1.24; 0.51; -0.79; -0.78), respectively, for boys. However, only 30-m sprint and velocity showed significant difference between selected and non-selected boys.

CONCLUSION: Although a tendency towards better physical performance is evident in the selected players of both genders, only 30-sprint and running velocity seems to be a discriminative attribute between selected and non-selected boys. A plausible explanation for better results in selected players might be increased exposure to systematic training.

KEYWORDS: Soccer, Talent identification, Sprint, Change of direction, Countermovement jump, Physical performance testing

SAMMENDRAG:

BAKGRUNN: Fotball er en kompleks idrett som krever at speidere og trenere vurderer en rekke fysiske karakteristika ved selektering av spillere til utviklingsmiljøer. Hensikten med dette studiet var å sammenligne fysiologiske testprestasjonsegenskaper hos spillere som ble valgt inn i et norsk talentutviklingsprogram (selekterte) med deres motparter (ikke-selekterte).

METODE: Nittiseks fotballspillere delt i grupper av selekterte og ikke-selekterte (selekterte jenter: n = 14, alder 14.8 ± 0.2 år; ikke-selekterte jenter: n =18, alder 15.5 ± 0.6 år; selekterte gutter: n = 16, alder 14.7 ± 0.3 år; ikke-selekterte gutter: n = 48, alder 14.7 ± 0.3 år) ble testet for 10-, 20-, og 30-m lineær sprint, hastighet m/s, retningsforanding (COD) dominant og ikke-dominant, og svikthopp (CMJ) i et innendørs laboratorium.

RESULTATER: Uavhengig t-test og Cohen's effektstørrelse (ES) ble brukt til å sammenligne gjennomsnitt. Gruppeforskjeller viste trivielle til store ES for 10-, 20-, 30-m sprint, hastighet, CMJ, og COD dominant, og ikke-dominant (0.15; -0.42; -0.35; 0.06; -0.57; -0.64; -0.43), henholdsvis for jentene, og (-0.93; -0,80; -1.04; 1.24; 0.51; -0.79; -0.78), henholdsvis for guttene.

KONKLUSJON: Selv om en tendens mot bedre fysisk prestasjon er tydelig hos selekterte spillere av begge kjønn, er det kun 30-m sprint og løpshastighet som ser ut til å være diskriminerende egenskaper mellom selekterte og ikke-selekterte gutter. En plausibel forklaring til de bedre resultatene hos selekterte spillere kan være økt eksponering for systematisk trening.

NØKKELORD: Fotball, Talentidentifikasjon, Sprint, Retningsforandring, Svikthopp, Testing av fysisk prestasjon

STRUCTURE OF THE THESIS

This thesis consists of three parts:

Part 1 presents the theoretical background for the study, a methodological chapter of how the study was performed, and a chapter discussing the methodology.

Part 2 presents a research paper, written in accordance with the guidelines from the open access International Journal of Sports Physiology and Performance. Part 2 consists of a IMRAD style manuscript: introduction, methods, results, discussion, practical applications, and conclusion.

Part 3 consists of appendices, approvals, and informed consents.

PART 1

THEORETICAL FRAMEWORK AND METHODS

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1 Introduction

Ever since the turn of the millennium, sports scientists, and researchers have been occupied with the substantive growth of research related to talent identification and development, with a variety of studies having attempted to offer empirical evidence on the prognostic value of different characteristics, abilities, and skills of young soccer players (Williams et al., 2020). Add to that the extensive expansion of women's soccer recently, there is an even bigger need to additionally provide empirical evidence of prognostic value contextualized for professional female soccer (Randell et al., 2021). Providing relevant information and tools for coaches and practitioners is important to allow them to nurture young players as they progress through development stage to professional adults (Williams & Reilly, 2000).

The multidisciplinary nature of soccer as a sport requires players to possess a wide variety of technical/biomechanical, tactical, mental, and physiological traits, the combined level of expertise has to be balanced among these traits to ensure success, rather than isolating expertise to only some of the traits (Stølen et al., 2005). The variety of characteristics required for soccer provides challenges for coaches and scouts participating in the identification process, which often rely on the evaluation of players current, rather than future performance (Sarmento et al., 2018; Williams et al., 2020). As young soccer players dynamically mature and develop at different rates, possess unique learning abilities, and gain diverse experience, a continuous assessment of characteristics crucial for expertise throughout the developmental years is important (Sarmento et al., 2018).

It is of our knowledge that powerful anaerobic bouts are important contributors to goals scored in professional soccer (Faude et al., 2012). Additionally, physical demands of professional soccer, especially in terms of high intensity running (HIR) and sprinting continues to increase (Allen et al., 2023)., hence why the relevance of investigating these attributes are important (Sarmento et al., 2018). Previous studies assessing motor performance have established speed, change of direction (COD), and power to be distinct characteristics that discriminate between selected and non-selected players (Forsman et al., 2016; Höner et al., 2021; le Gall et al., 2010; Leyhr et al., 2020), thus providing evidence for relevant physical attributes to assess in physical performance tests (Sarmento et al., 2018). With soccer being a sport that consists of repeated short sprints, rapid accelerations and decelerations, changes of direction, and jumping, it comes as no surprise that specific motor performances are decisive as the professional game concurrently become physically and technically more demanding (Bush et al., 2015). During a soccer game the activity profiles for male and female players consists of roughly ~1300 of these mainly brief locomotor activities, of which many are explosive of nature (Randell et al., 2021; Stølen et al., 2005).

With large participation rates, associations and clubs do not necessarily have sufficient resources to nurture all the players taking part in soccer, thus early talent selection is a necessity to provide adequate development programs for talented players. In context of this study, selection of talented players to the Norwegian talent developing program is solely based on coaches' subjective evaluation of players (Sieghartsleitner et al., 2019). Although certain criteria's are present during evaluation, often the outcome of it is reliant on the coaches innate image of important attributes the player has to possess (Sieghartsleitner et al., 2019). Thus, evaluation of influential physical attributes provides objective relevance to the otherwise subjective evaluation of players (Sieghartsleitner et al., 2019; Williams et al., 2020). Furthermore, as speed, COD, and power are determinants of success (Dos'Santos et al., 2022; Faude et al., 2012), monitoring these abilities during development are important due to their prognostic value (Williams et al., 2020). With the increased focus on physical performance in modern soccer, the present study aims to examine the potential differences in physical test performance of youth soccer players selected into a talent development program and their non-selected peers within both male and female players.

1.1 Overall Goal and Purpose

Thus, the main goals of this research project were:

1. To examine the potential differences in physical test performance of youth soccer players selected into a talent development program and their non-selected peers within both male and female players.
2. To determine whether possible differences between test performance of selected and non-selected players offers any discriminative value for selection process.

2 Theoretical background

The following part consists of three parts:

Part (1) represents the theoretical framework for the research project, which begins with contextualisation of talent, talent identification, and how it is implemented in soccer. Furthermore, the theory part provides empirical evidence on the physical demands of soccer, and how separate motor performance abilities influence it.

Part (2) presents information of the study design, its participants, test protocols, statistical analyses, and ethical considerations.

Part (3) is the methodological discussion that in depth reasoning for the chosen study design, participants, and further evidence for the inclusion of selected tests for motor performance in the present study. Lastly followed up by strengths and limitation related to the present research project.

2.1 Talent

The word talent is a widely used, complex term in difference contexts within the society (Till & Baker, 2020). In the literature talent is often referred to as innate abilities that an individual predisposes (are born with), which manifests as the final product, or learning process within a field of interest (Gagné, 2010; Johnston et al., 2018; Nijs et al., 2014; Sarmento et al., 2018; Till & Baker, 2020). One broad view of talent in the society has been Gagne's *Differentiated Model of Giftedness and Talent*, which distinguishes giftedness and talent, by referring to them as a progressive transformation, that places the individuals among the top in aged peers (Gagné, 2004, 2010). Giftedness is explained as the born element of innate abilities, whereas talent is the acquisition of the abilities through mastering them (Gagné, 2004, 2010). In the field of sport, a more recent conceptualization of what talent is has emerged, in which multiple aspects are composed as the natural abilities and capacities interact, emerge and evolve around the society and environment they are developed within (Baker et al., 2019). Even though a clear definition of talent still does not exist, concluded talent can be described as a precondition which develops into an outcome (Baker et al., 2019; Sarmento et al., 2018).

2.2 Talent identification

In the sporting world, talent identification processes are an integral part of the sport in order to identify and predict which individuals possess the most potential to achieve future success

(Reilly et al., 2000). This is evident by looking at the vast amount of money governing institutes, private investors, clubs, and national federations invest in different developmental programs in order to either attain expertise or remain the best (Rees et al., 2016; Williams et al., 2020). A large proportion of the investment concerns the ability to identify the most gifted athletes at a young age, and to financially invest in promoting them to achieve success in their sport through expert coaching, training, competition, and support (Vaeyens et al., 2009; Williams & Reilly, 2000). Talent identification allows these valued athletes to develop their expertise on other terms, which puts them on a pedestal compared to athletes deemed less talented at the time of selection (Vaeyens et al., 2009). It seems like deliberate practice proposed by Ericsson et al. (1993) is used as the motive for early promotion to talent programmes, and is seen as a necessity for international success at senior level (Johnston et al., 2018; Rees et al., 2016; Vaeyens et al., 2009). Although this might be true for certain sporting events that require a very specific motor-skill, this is not necessarily true for other sports requiring a more complex skill acquisition (Barreiros et al., 2014). A retrospective study by Barreiros et al. (2014) on Portuguese athletes showed that the majority of the athletes that were selected for junior teams did not achieve success at senior level. One of the reasons might be that the athletes were selected to junior teams based on current performance and maturity status to promote short-term success (Vaeyens et al., 2009; Wattie et al., 2015).

A previous study on expert ball sport athletes by Baker et al. (2003) revealed that players whom were chosen to represent their national teams had accumulated experience through a variety of sports during their childhood, rather than only the specific sport where they achieved expertise. Another study of national team athletes revealed an increased number of diverse activities until early adolescence, which further strengthens the suggestion that early specialization is not necessarily needed for ball sports (Leite et al., 2009). It seems that sports that share similar characteristics, especially ball sports, which require constant decision-making and reactions in a dynamic environment offers a diverse accumulation of skills that are well transferrable between the sport-specific domains (Baker et al., 2003; Leite et al., 2009). These findings by Baker et al. (2003) and Leite et al. (2009) are quite contradictive to the short-term priorities that emphasizes early specialization for success (Baker et al., 2018).

Based on these findings, talent identification in sports is the process of identifying individuals that has the potential to excel in a particular sport, and to provide them with the necessary training and support to achieve their full potential. Identifiers need to be aware of the sport specific skills in relation to their sport and which prognostic value they offer for future success.

2.3 Talent identification in soccer

As the aim of the present research project is not the entity of the multidisciplinary view, the following sections will first briefly explain the coach knowledge in talent identification, before turning the view towards the focus of physiological characteristics in talent identification (Murr, Raabe, et al., 2018; A. H. Roberts et al., 2019).

Along with other team-based ball sports, soccer is a complex sport relying on a combination of skills rather than just being mechanistic, as many individual sports tends to be (Reilly et al., 2000; Williams & Reilly, 2000). To take issue into matter, Reilly et al. (2000) proposed a multidisciplinary approach to talent identification for coaches, practitioners and others working with talent identification and development. The aim was to predict and identify characteristics that could discriminate between those that are more skilled or talented from those less skilled or talented (Reilly et al., 2000). The potential predictors in a multidisciplinary view was; *physical predictors* (height, weight, body size, bone diameter, muscle girth, somatotype, growth, body fat), *sociological predictors* (parental support, socio-economic background, education, coach-child interaction, hours in practice, cultural background), *psychological predictors* (perceptual-cognitive skills; attention, anticipation, decision making, game intelligence, creative thinking, motor/technical skills, and personality traits; self-confidence, anxiety control, motivation, concentration), and *physiological predictors* (aerobic capacity, anaerobic endurance, anaerobic power) (Williams & Reilly, 2000).

The same year Williams and Reilly (2000) proposed the multidisciplinary approach, Reilly et al. (2000) conducted a study using a multidisciplinary test battery to distinguish sub-elite and elite youth soccer players by measuring anthropometric, physiological, psychological and performance. The results revealed that elite players scored better than the sub-elite players in most of the measured variables using a comprehensive test battery, with COD, speed, motivational orientation and anticipation skill being the most distinguishable between the two groups (Reilly et al., 2000).

After Williams and Reilly (2000) and Reilly et al. (2000) highlighted the need for a more multidisciplinary and longitudinal approach to describe talent identification, an updated review on the subject matter was done by Williams et al. (2020). The updated review shows that during the period from the original article back in the turn of the millennium there has been several studies with a multidisciplinary and longitudinal approach which has led to some empirical evidence of variables that predict later elite performance levels (Williams et al., 2020). The variables that seem to have the most predictive evidence are those related to *physical attributes, skill attributes, psychological attributes,* and *sociological attributes*, while some other variables, such as *maturation, development environment, external environment,* and *chance events* having less predictive evidence (Williams et al., 2020).

As Williams et al. (2020) highlighted the need for a variety of predictors to consider in the talent identification process, another review by Murr, Feichtinger, et al. (2018) presented some evidence of prognostic value of psychological predictors in soccer. The prognostic value highlighted that psychomotor (dribbling, ball control), perceptual-cognitive (positioning and deciding, knowing about ball actions, knowing about others, acting in changing situations) and personality-related (mental skills, motivational orientation, goal commitment, self-determination) are psychological dispositions that can discriminate between youth players of different performance levels, with especially dribbling, decision-making and achievement motive being the most predictive (Murr, Feichtinger, et al., 2018).

The most common way talent identification is evaluated, is that it is done by expert coaches and scouts whom identify and predict the potential of possible future elite athletes (A. H. Roberts et al., 2019). Often the identification of players are done based on current match performances, before they are recruited into development programs (Williams et al., 2020). A continuing pattern seems to be, that coaches and scouts implicitly rely on an instinctive basis when defining talent, based on a foundation of knowledge and earlier experience (Christensen, 2009; A. H. Roberts et al., 2019). This subjective preconceived image of a player (Williams & Reilly, 2000) is often referred to as “the coaches’ eye” in the literature (Christensen, 2009; A. H. Roberts et al., 2019; Sieghartsleitner et al., 2019). Usually, the basis of these instinctive actions are based on the coaches education, experience and interaction with other colleagues, which in the domain of talent identification excels them to be the expert (Jokuschies et al., 2017).

Although many coaches inherit their own experiences and preferences when judging individuals for development programmes, there are common characteristics that coaches across the sporting spectre value more than others (Christensen, 2009; Fuhre et al., 2022; Jokuschies et al., 2017; A. H. Roberts et al., 2019). Usually that experience stems from continuously acknowledging what the international requirements are, through constant observation of players, to create a picture of what to seek after (Christensen, 2009). The coaches subjective evaluation of players were called coaches “eye” by Christensen (2009), which as a phenomenon is dynamic, with coaches and practitioners having different perceptions of which qualities they value in their assessment, hence why quantitative measurement of it is challenging (Bergkamp et al., 2022; Fuhre et al., 2022; Jokuschies et al., 2017; Larkin & O’Connor, 2017; Sieghartsleitner et al., 2019).

In terms of characteristics, the players technical ability on the ball, such as dribbling, passing, shooting, and controlling the ball are viewed by coaches and practitioners as highly important attributes (Bergkamp et al., 2022; Fuhre et al., 2022; Larkin & O’Connor, 2017). Especially ball control (Bergkamp et al., 2022; Larkin & O’Connor, 2017) and technique under pressure receiving the most practical value (Larkin & O’Connor, 2017). Another characteristic deemed often highly important by coaches and practitioners is the perceptual-cognitive skills related to tactical attributes, such as decision-making, game sense and awareness, anticipation, and general understanding of the game (Bergkamp et al., 2022; Fuhre et al., 2022; Larkin & O’Connor, 2017; S. J. Roberts et al., 2019). Other psychological characteristics as winning mindset or mentality (Bergkamp et al., 2022), coachability, positive attitude (Larkin & O’Connor, 2017), and other personality traits, such as achievement motivation, volition, self-confidence, self-assessment, taking responsibility, and coping are seen as important attributes (Jokuschies et al., 2017).

In recent literature regarding coaches’ view, there seems to be a consensus in regards of the importance of technical and psychological attributes of the athletes (Bergkamp et al., 2022; Fuhre et al., 2022; Jokuschies et al., 2017; Larkin & O’Connor, 2017; S. J. Roberts et al., 2019). In terms of anthropometric and physiological attributes, some coaches do not view it as particular importance in the identification process of players, but rather acknowledge that these are also important factors, which can be influenced through maturity and development (Fuhre et al., 2022; Larkin & O’Connor, 2017; S. J. Roberts et al., 2019). Contradictive to the aforementioned coaches’ views of these attributes, other coaches has highlighted specific characteristics, such as athleticism (Mills et al., 2012), speed (Bergkamp et al., 2022; Jokuschies et al., 2017; Mills et al., 2012), coordination, COD (Bergkamp et al., 2022; Jokuschies et al., 2017), and general motor skills and physical attributes (Bergkamp et al., 2022).

In summary scouts and coaches who identify talented players rely on their "gut instinct" when assessing them (A. H. Roberts et al., 2019), which is an intuitive ability amongst experts to recognize attributes deemed important for future performance, but also one that they have difficulties in describing (Bergkamp et al., 2022; Christensen, 2009). Coaches and scouts seem to value a collection of attributes, suggesting that their approach is multidimensional (Bergkamp et al., 2022; Fuhre et al., 2022; Jokuschies et al., 2017; Larkin & O'Connor, 2017; Mills et al., 2012; S. J. Roberts et al., 2019), and are in accordance with the multidisciplinary approach that has been suggested (Reilly et al., 2000; Unnithan et al., 2012; Williams et al., 2020)

2.4 Physical demands in soccer

The total distance covered is an indicator of the total volume and activity completed by players and despite variation, professional male and female players generally cover ~10 km during competitive matches (Andersson et al., 2010; Andrzejewski et al., 2016; Bradley et al., 2013; Bradley et al., 2010; Bradley et al., 2009; Gabbett & Mulvey, 2008; Krustrup et al., 2005; Mohr et al., 2008; Mohr et al., 2003; Rampinini et al., 2007; Rampinini et al., 2009; Reynolds et al., 2021; Vescovi, 2012). In regards to positional differences of the outfield players, central midfielders usually cover the greatest distance, followed by wide midfielders, fullbacks, and attackers, whilst central defenders covers the least distance (Abbott et al., 2018; Bradley et al., 2010; Dalen et al., 2016; Ingebrigtsen et al., 2015; Modric et al., 2019) A review written by Palucci Vieira et al. (2019) shows a linear development of total distance covered in young soccer players from age eight years and upwards, where the distances covered by players aged 17 – 20 years are closely related to those of professional adults. For more specific activity patterns during match play, players cover around ~80% of the total distance in low-intensity activities as standing, walking, and jogging (Bradley et al., 2009; Dalen et al., 2016; Ingebrigtsen et al., 2015; Modric et al., 2019; Vigne et al., 2010). The amount of activity spent in low-intensity activities explains why the aerobic energy system accounts for 70 – 90% of the total energy consumption during match play (Hostrup & Bangsbo, 2023), with a mean heart rate corresponding to approximately 85% of max (Andersson et al., 2010; Krustrup et al., 2005). It is however important to note that the anaerobic processes become vital when players perform intense actions such as accelerations, sprints, jumps, and changes of direction (Hostrup & Bangsbo, 2023). Anaerobic bouts can also be crucial for match outcomes, as was shown in a previous study of the German

Bundesliga, where at least one powerful action from either the scoring or assisting player was observed in 83% of all scored goals (Faude et al., 2012).

2.4.1 High-intensity running and sprinting

With the ever increased interest amongst scientists and practitioners to measure HIR and sprinting in soccer, various methods and speed thresholds has been implemented in the literature (Gualtieri et al., 2023). In most studies the threshold for sprinting speed is set at >25.2 km/h (Allen et al., 2023; Bradley et al., 2010; Bradley et al., 2009; Dalen et al., 2016; Ingebrigtsen et al., 2015; Modric et al., 2019; Reynolds et al., 2021), although thresholds of >24.1 km/h (Dellal & Wong, 2013), >23 km/h (Di Salvo et al., 2007), and >19 km/h (Vigne et al., 2010) also has been used. The utilization of different thresholds across the literature, may cause challenges, hence why the thresholds for women's and men's official competitions of Union of European Football Association (UEFA) and Fédération Internationale de Football Association (FIFA) are 19 km/h and 23 km/h, respectively, for HIR and 20 km/h and 25 km/h, respectively, for sprinting (Gualtieri et al., 2023). In case of the sections below, HIR and sprinting will be characterized as 19.8 – 25.2 km/h and >25.2 km/h, respectively, unless otherwise stated.

In terms of HIR the physical demands of international soccer is ever increasing, as shown by Barnes et al. (2014) who found that the distance and frequency of HIR increased ~30% and ~50%, respectively, across seven seasons between 2006/2007 and 2012/2013 in the English Premier League (EPL). In women's football a similar trend has been observed in the 2019 World Cup, with a 15% increase in HIR distance compared to the 2015 World Cup (Bradley & Scott, 2020). Other previous studies on professional players across different nations have reported following values of HIR; Croatian 6.4% (Modric et al., 2019), Norwegian 7.6% (Dalen et al., 2016) and 7,5% (Ingebrigtsen et al., 2015), Spanish and English 3.9% (Dellal et al., 2011), and Italian 8.4% (Vigne et al., 2010). It must be however noted that the studies of Dellal et al. (2011) and Vigne et al. (2010) used thresholds of 21 – 24 km/h and 16 – 19 km/h, respectively, which partly can explain the discrepancies across studies. The amount of HIR is also position dependant, with wide midfielders and fullbacks reporting the highest values, followed by central midfielders and attackers, with central defenders covering the least HIR (Bradley et al., 2009; Dalen et al., 2016; Dellal et al., 2011; Di Salvo et al., 2007; Ingebrigtsen et al., 2015; Lago et al., 2010; Modric et al., 2019). These variations across positions are also evident for women (Bradley & Scott, 2020).

Similarly to HIR, the research of Barnes et al. (2014) revealed that the distance and frequency of sprints increased by ~35% and ~85%, respectively, across the same period across seven seasons. Bradley and Scott (2020) found that for women there was a 29% increase in sprint distance between the two World Cups. Reports on positional differences shows that in line with HIR, fullbacks and wide midfielders covers the most sprint distance, followed by attackers and central midfielders, with central defenders sprinting the least (Bradley et al., 2009; Dalen et al., 2016; Dellal et al., 2011; Di Salvo et al., 2007; Ingebrigtsen et al., 2015; Lago et al., 2010; Modric et al., 2019). For women positional differences are slightly different, with wide midfielders and forwards covering the most distance, followed by fullbacks and central midfielders, with central defenders reporting the lowest distances (Bradley & Scott, 2020). The importance of sprinting in match play is further strengthened by the study of Faude et al. (2012), which reported straight sprinting as being the most frequent powerful action for goal scorer (38%) and assisting player (45%).

To explain the positional differences when it comes to HIR and sprinting, one must investigate the complexity of the tactical and technical aspects of the game. It seems that the total amount of HIR and sprinting is a result of the tactical disposition of the different positions (Di Salvo et al., 2009). Wide midfielders and attackers that must utilize their sprinting abilities to dribble their opponents to create space and scoring opportunities for themselves and their team, whereas the high values for full-backs seems to be the result of their need to support the play in both defensive and attacking sense in modern soccer tactics imposed by many teams (Di Salvo et al., 2009). The measurements of wide midfielders and attackers are in correlation with the data from Bradley et al. (2009) whom reported 6 – 8% higher maximum running speeds compared with central defenders, which can be explained by the length of the HIR, giving them more time to accelerate and reach their top speeds. The lower values for the central defenders are likely due to the position being more involved in defensive actions (Di Salvo et al., 2009). For central midfielders the tendency for sprints seems to be more of explosive nature, whereas for the wide midfielders and attackers the completed sprints were leading (Di Salvo et al., 2009). These differences also seem to be related to the involvements in play, where the central midfielders operate in tighter space occupied by more players with less expressive freedom, which results in shorter actions of intensive bursts (Di Salvo et al., 2009).

Though HIR and sprinting is an integral part of a soccer match, one must be careful in making presumptions that success is only based on this alone at the highest level (Mohr et al., 2008; Mohr et al., 2003). A study of Rampinini et al. (2009) showed that the less successful teams in the Italian Serie A had higher total distance (4%), high intensity running (11%) and very high intensity running covered (9%) compared to the most successful teams. On the other hand, the most successful teams had a higher total distance with the ball (18%) and high intensity with the ball (16%), as well as higher technical involvements with the ball (Rampinini et al., 2009). This seems to be an indication that the most successful teams in tactical sense enjoyed a larger amount of the game with the ball in possession of the team, which allows them to dictate the game tempo, whilst the opposition has to attempt to regain possession of the ball, resulting in an elevated need to perform high- and very high intensity running (Bradley et al., 2013; Di Salvo et al., 2009; Rampinini et al., 2007; Rampinini et al., 2009). A study of Real Madrid revealed similar trends that the players performed less HIR and sprints than the opposing teams during, due to the probability that the Real Madrid players were technically and tactically more advanced, allowing them to dictate the play to suit their style (Miñano-Espin et al., 2017).

In summary, HIR and sprinting is a pivotal part of soccer games and there is an ever increasing need for the players to perform more of these actions. Barnes et al. (2014) brought forth clear evidence of this evolving pattern, with an even more recent study of Allen et al. (2023) highlighting that HIR and sprinting in EPL has increased with an additional 12 and 15%, respectively, between 2014/2015 and 2018/2019. The required demands of HIR and sprinting are position-specific, with some positions requiring more than others. It is however important to consider, that HIR and sprinting with the ball in possession can lead to increased successful actions offensively (Modric et al., 2022).

2.4.2 Speed

With sprint bouts occurring approximately every 90 seconds during a soccer game, it is evident that speed abilities of players are an integral part of their combined assets (Stølen et al., 2005). During a game the total number of sprints for players are between 40 – 60 (Hostrup & Bangsbo, 2023) with each sprint bout lasting approximately 2 – 4 s (Mohr et al., 2003; Vigne et al., 2010). Previous studies by Faude et al. (2012) and Martínez-Hernández et al. (2023) revealed that straight line sprinting the most frequent action of both the scoring player, and the assisting player in professional soccer, highlighting the significance of speed for game outcome. Speed abilities are influential for several situations on the field. For attackers it can help beat defenders, create space for themselves, break through defensive lines, and to receive balls being played in to space (Di Salvo et al., 2007). Midfielders can utilize their speed abilities in the different transitions of the game to create space and opportunities, but also defend when necessary (Di Salvo et al., 2007). For a defender speed can help closing down opponents, preventing them the opportunity to create scoring opportunities (Di Salvo et al., 2007).

Speed ability is a characteristic that improves with age during adolescence for both males and females, with older players outperforming those of younger in sprint tests (Emmonds et al., 2016; Loturco et al., 2018; Vescovi et al., 2011), with sprint velocity peaking in players between 20 – 28 years of age (Haugen et al., 2013). Previous literature on sprint times in male professionals has reported 10-m sprint times with a range of 1.69 – 1.82 s (Cometti et al., 2001; Cotte & Chatard, 2011; Haugen et al., 2013; Wisløff et al., 2004), 20-m sprint times with a range of 2.75 – 3.00 s (Cotte & Chatard, 2011; Haugen et al., 2013; Wisløff et al., 2004), and 30-m sprint times with a range 3.89 – 4.22 s (Cometti et al., 2001; Haugen et al., 2013; Wisløff et al., 2004). For peak velocity in 20 – 30 m split Cotte and Chatard (2011) and Haugen et al. (2013) reported a range of 8.57 – 8.90 m/s. Furthermore, in the study of Cotte and Chatard (2011) international players had slightly faster split times and higher velocity compared to non-international players. Interestingly the study by Haugen et al. (2013) revealed that sprinting times has slightly improved between 1995 – 2010, thus it is plausible to believe that the relatively old results from the studies of Cometti et al. (2001) and Wisløff et al. (2004) are outdated. For female Norwegian national team players and English elite players the range for 10, 20, and 30-m sprint times are 1.67 – 1.87, 3.05 – 3.21, and 4.35 – 4.52 s (Emmonds et al., 2019; Haugen et al., 2012), respectively, with peak velocity of 7.7 m/s in the study by Haugen et al. (2012). Similarly to males, Haugen et al. (2012) revealed and improvement in sprint capabilities for females between 1995-2010, especially for the 0 – 20 m distance.

In summary, sprinting as an ability in soccer is highly important, especially during crucial, match defining moments of play. Although sprinting performance of soccer players are widely examined in the literature, testing vary a lot in terms of distances measured, competitions levels, equipment used for measurement, environmental factors, surface, and time of the season, thus making direct comparisons across literature difficult.

2.4.3 Change of Direction

The ability to change direction during soccer play is along with speed considered an essential part of high level performance (Brughelli et al., 2008). COD is across literature often referred to agility, which Sheppard and Young (2006) defined as a rapid whole-body movement with change of velocity or direction in response to a stimuli. As a part of agility, COD can be defined as a sub-component of agility, which is a movement requiring a turn without external stimulus (Brughelli et al., 2008). Factors that are considered important for COD ability include technical, speed, and strength/power qualities (Sheppard & Young, 2006). In soccer play COD is persecuted by rapid movement before the player decelerates in order to be able to make a directional change, followed up by a new acceleration (Harper et al., 2019). Previous study on the turning demands of soccer play revealed that male players in EPL perform approximately ~700 turns of 0 – 360°, with most of them being 0 – 90° and 90 – 180° of nature (Bloomfield et al., 2007). The high amount of turning demands is also related to performance success, with Faude et al. (2012) reporting rotation and COD being the third most frequent action for scoring players, while rotation and COD were the second and third most frequent action for assisting player. Similarities became evident in a more recent study by Martínez-Hernández et al. (2023) where turns and decelerations, respectively, were the second and third most frequent actions for both scoring and assisting player. With advances in technology, new methods of measuring turning demands emerges. Dos'Santos et al. (2022) utilized a tracking system to quantify the turning demands of EPL based on entry speed (m/s) and turning angle. Positional differences revealed that midfielders performed the highest amount of turns compared to other positions (Dos'Santos et al., 2022). Overall, approximately 90% of turns were performed with entry speed <5.5 m/s and ~63 – 70% were 120 – 180° turns (Dos'Santos et al., 2022).

Summarized, directional changes requiring players to accelerate and decelerate are integral high-intensity actions in soccer play that directly affects performance. A large number of COD tests with varying lengths and amount of turns are used in literature shows that there is a lack of consensus regarding use of correct tests, which makes comparison of results challenging (Brughelli et al., 2008).

2.4.4 Power and Strength

Power can be defined as the working muscle's ability to produce maximal force with highest possible velocity (Cormie et al., 2011; Kraemer & Newton, 2000). In sporting context, a powerful action is often referred to as an explosive burst of action (Datson et al., 2014; Stølen et al., 2005). As the contractile capacity of muscles involved dictates maximal power generation, several morphological factors such as muscle fibre type, cross-sectional area, fascicle length, pennation angle, and tendon properties are influential (Cormie et al., 2011).

Additionally, neural factors in the nervous system, such as motor unit recruitment, firing frequency, motor unit synchronization, and inter-muscular coordination contribute to maximal power (Cormie et al., 2011).

Maximal power being an explosive burst of action, it is regarded as an element dictating sport specific skills as sprinting, jumping, COD, throwing, kicking, and striking (Cormie et al., 2011; Kraemer & Newton, 2000; Young, 2006). With most of these mentioned sport specific skills being present in soccer, it is natural to regard power as an integral part of success in soccer (Datson et al., 2014; Stølen et al., 2005). During soccer play both horizontal and vertical power outputs are present in ball possession, regaining possession, corner kicks, and defensive and offensive situations (Haugen et al., 2013). The previously discussed study by Faude et al. (2012) revealed that jumping action was the second and third most common action for scoring and assisting player, respectively. In contrast Martínez-Hernández et al. (2023) found out that jumps were amongst the least occurring high-intensity actions leading to a goal, but this could also be down to differences in playing styles of the leagues these researchers studied (Faude et al., 2012; Martínez-Hernández et al., 2023).

For measurement of power vertical jumps, or more precisely CMJ is widely accepted in the literature as a valid test method due to its similarity for physical skills executed in soccer (Datson et al., 2014; Kraemer & Newton, 2000; Paul & Nassis, 2015; Stølen et al., 2005). Several previous studies have utilized CMJ as measure of power when defining power capabilities of both male, and female professional players (Boone et al., 2012; Mujika et al., 2009; Sporis et al., 2009; Wisløff et al., 2004). Furthermore, a plethora of studies have investigated CMJ results across different playing levels, with players of higher standard usually reporting a trend towards higher values (Castagna & Castellini, 2013; Haugen et al., 2012, 2013; le Gall et al., 2010; Saward et al., 2020; Vescovi et al., 2011). Development of power abilities has proven to improve in line with chronological age, with females showing improvement until 15 – 16 years after which it plateaus until senior level (Vescovi et al., 2011), whereas males performance improve up until senior age (Loturco et al., 2018). Other studies have also reported a stagnation in performance when reaching senior level (Castagna & Castellini, 2013; Haugen et al., 2012, 2013). The studies of Castagna and Castellini (2013) and Loturco et al. (2018) actually reported a tendency towards impaired jump performance on senior level. Furthermore, they hypothesized that detriments in performance was related to the higher volumes of technical and tactical training in senior soccer, at the expense of neuromuscular training (Castagna & Castellini, 2013; Loturco et al., 2018).

Whereas power is the working muscle's ability to create maximal force, with as much velocity as possible, strength is the ability to exert maximal force on an external object or resistance (Suchomel et al., 2016). In fact, strength is considered the foundational element required for power, with stronger individuals being able to produce force faster than weaker individuals (Haff & Nimphius, 2012). With strength serving as the foundation for several abilities, it has been recommended that training that increases maximal strength should be emphasized at early stages, or for weaker individuals (Haff & Nimphius, 2012; Suchomel et al., 2018). When an individual reaches high levels of strength, further improvements diminish, thus a shift towards more power focused training is suggested (Kraemer & Newton, 2000). It has been suggested that strength levels of two times body weight in back squat is required to elicit high level athletic performance in team sports such as soccer (Stone et al., 2002; Wisløff et al., 2004). As strength training causes the skeletal muscles to grow and increase total body mass, they additionally provide better stability and coordination (Young, 2006). Simultaneously muscles serves as a protective layer for vital soft tissues and bones (Young, 2006). Interestingly, a previous meta-analysis that looked into sports injuries revealed that strength training protocols reduced sports injuries to one-third, while overuse injuries could be almost halved (Lauersen et al., 2014).

In summary power capabilities of players are crucial to efficiently perform sports specific skills as sprinting, jumping, COD, throwing, kicking, and tackling. A foundation of high maximal strength is pivotal for development of power abilities. Additionally improved strength can prevent injuries from occurring.

3 Methods

The aim of the present study is to examine the potential differences in physical test performance of youth soccer players selected into a talent development program and their non-selected peers within both male and female players. In the context of the present study the term selected represents the players selected into the national team development program, in which they are a part of a regional team that undertake additional training and games directed by The Norwegian Football Association (NFF), whereas non-selected represents the players that are members of local clubs.

3.1 Study design

This study used a cross-sectional research design to compare physiological characteristics between players selected into the Norwegian talent development programme, and those that are not selected. All participating players were playing for different local U15 teams in the region. Additionally, some of these players are annually selected to be part of a regional team under the Norwegian talent development program, categorized as selected players in this study. Selected players were recruited through the regional team and being a part of the team at the time of testing was a prerequisite, with the non-selected peers being recruited through their respective club and U15 team.

Data collections were carried out in an indoor lab-environment over a three-week period during the pre-season period between February and March 2023, conducted over nine separate test days. All the tests were carried out at the same time of day, between 3 pm and 8 pm.

3.2 Participants

A total of ninety-six female and male soccer players participated in the present study, divided into different gender and which of selected, or non-selected category they belong to (Selected girls: n = 14; Non-selected girls: n =18; Selected boys: n = 16; Non-selected boys: n = 48). Of the participants, eleven players (n = 1 selected girl; n = 2 non-selected girls; n = 4 selected boys; n = 4 non-selected boys) were excluded from sprint testing due to being goalkeepers. Additional four players (n = 1 selected girl; n = 3 non-selected boys) failed to register a result on either the dominant, or non-dominant COD test. Written informed consent was obtained from all players and their guardians before the study commenced. Players were made aware of inherent risks and benefits associated with the study. The study was carried out according to the Declaration of Helsinki and approved by the Ethics Committee of the Faculty for Health and Sports Science, University of Agder, and by the Norwegian Agency for Shared Services in Education and Research.

3.3 Testing procedures

Testing was performed at the lab facilities of the University of Agder, Norway. The following physical tests and measurements were carried out in one test session: anthropometry (height, weight), 30-m sprint, CMJ, strength test and COD test. In addition, all participants preferred playing position and date of birth was registered. Participants were in advance encouraged to refrain from strenuous exercise 24 hours prior to testing. All tests were performed on the same time of day, with the same equipment in a controlled indoor environment, overseen by the same trained instructors. Prior to the physical tests the participants measured their height and weight and took part in a 10-min warm-up consisting of dynamic movement and stretching, followed up by three progressive 30-m sprints of 60%, 80% and 90% that of maximum. All participants carried out the 30-m sprint test initially, before being randomly allocated to either CMJ, strength, or COD test.

3.4 30-m sprint

All participants performed three maximal 30-m sprints on an even indoor sports floor with a synthetic surface, separated by a three-minute recovery between each sprint to ensure sufficient recovery between each sprint. Time was measured with dual beamed photocells (MuscleLab 20, version 10.201.93.0, Ergotest, Norway) placed with 10-m intervals to measure time between distances (i.e., 0 – 10, 10 – 20 and 20 – 30 m.). Each sprint started from a standing position with the leading foot slightly behind the first timing gate. Each participant was verbally instructed to sprint as fast as possible past the furthest timing gate. The best single 30-m attempt together with best 10-m and 20-m splits were retained for analysis. 30-m sprint has intraclass correlation coefficients (ICC) of 0,80 – 0,98 amongst youth and elite athletes (Pareja-Blanco et al., 2016; Rumpf et al., 2011; Sporis et al., 2009).

3.5 CMJ

Maximal vertical jumping ability were performed using a portable force platform (AMTI, Advanced Mechanical Technology Inc, USA). Participants performed three jumps interspersed with approximately 30-s rest between each jump. Each jump was performed with hands kept on the hips and participants were instructed to perform a self-assessed downward movement followed by a maximal vertical jump (Lindberg et al., 2022). The best jump attempt measured in centimetres was retained for analysis. The CMJ has proven to be a reliable way of measure with reported ICC of >0.88 (Lindberg et al., 2022; Loturco et al., 2015; Sporis et al., 2009)

3.6 Strength test

Lower extremity strength was measured using a Keiser Air300 horizontal leg press dynamometer (Keiser Sport, Fresno, CA), which uses pneumatic resistance to measure force and velocity in each repetition. The testing procedure consisted of an incremental loading 10-repetition test pre-programmed in the Keiser A420 software. For the participants of this study an expected 1RM was pre-determined as 180 kg for the girls and 210 kg for the boys on the 10th repetition. The test started with two practice attempts at a light load, followed by gradually increasing load for each repetition until reaching the pre-determined 1RM load on the 10th repetition. Attempts beyond the 10-repetition range was executed with equivalent increase in load until the participant failed to perform the repetition. The rest period between repetitions was aligned, meaning the rest periods got longer as the load increased. Before the start of each test, the seated position was adjusted to 90° knee-joint angle for each participant. The participants were instructed to push as explosively as possible during each repetition until failure. Maximal power measured in watts was retained for analysis. The leg press has previously been proven to have a good reliability (ICC >0.98) for measurement of maximal power in athletes (Lindberg et al., 2022).

As the main objectives of the present study was to compare characteristics of selected and non-selected groups, an acceptable decision of excluding test results in its entity were done due to a malfunction of the machine used for testing.

3.7 COD

Ability to COD were measured using the OLT40 agility test, which is a modification of the S180° test described by Sporis et al. (2010). In the OLT40 the participant executes a 12.5 m linear sprint, followed up by four right or left 180° turns with 5 m distance in between them, finished off with another 12.5 m linear sprint to the end line (total distance 40 m). The starting position was the same as for the sprint test. Each turn had to be made with the same foot and had to cross the lines. Being in contact with a line during any of the turns would lead to a failed attempt. Time was measured with portable TCi system (Brower Timing System, USA). The participants performed two attempts with both right and left foot, with a total of four attempts, separated by a three-minute recovery between each attempt. The best attempt of both feet was retained for analysis. For measurement of COD, the test has proven to be a reliable (ICC 0.94) method (Sporis et al., 2010). The OLT40 agility test setup is illustrated in Figure 1.

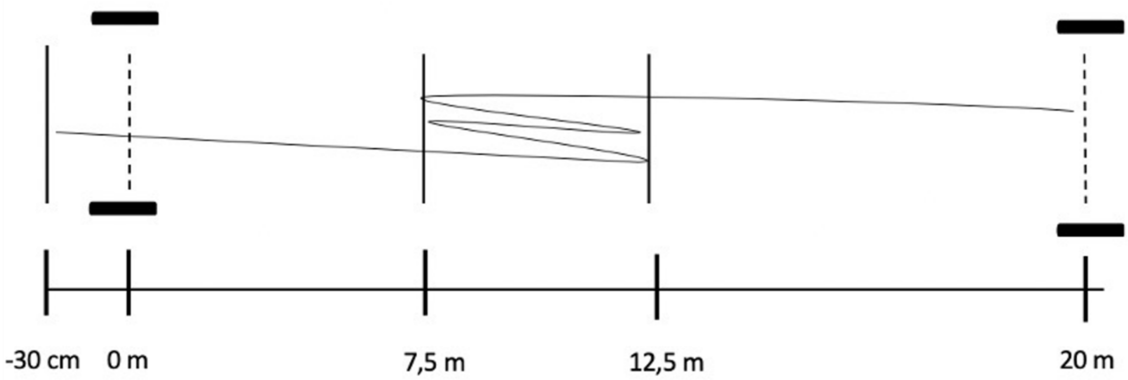

FIGURE 1 | Illustration of the OLT40 agility test

3.8 Statistical analysis

All statistical analyses were performed using SPSS (Version 28.0. Armonk, NY: IBM Corp) and Microsoft Excel version 16.0 (MS, Redmond, WA). Normal distribution was confirmed using Q-Q plots, Shapiro-Wilk test, and visual inspection of variable histograms. Data are presented as mean ± standard deviation (SD) and 95% confidence interval (CI). Independent samples t-test were used to investigate differences between selected and non-selected players of both genders. Cohen's *d* effect sizes (ES) with ES <0.2, 0.2 – 0.6, 0.6 – 1.2, 1.2 – 2.0, and >2.0 considered trivial, small, moderate, large, very large and extremely large, respectively, to compare the magnitude of the differences between selected and non-selected (Hopkins et al., 2009) The level of significance was set at $p < 0.05$ for all statistical analyses.

3.9 Ethical considerations

The study was carried out according to the Declaration of Helsinki and approved by both the Ethics Committee of the Faculty for Health and Sports Science, University of Agder, and by the Norwegian Agency for Shared Services in Education and Research (ref. no. 520969). All participants and their guardians signed a written informed consent form prior to participation and were made aware of inherent risks and benefits associated with the study. Participants were also made aware of the possibility to withdraw from the project at any time without any further consequences or need of an explanation. All data collection were done anonymously and could not be traced back at individual level.

4 Methodological discussion

4.1 Study design

A cross-sectional research design was used to compare physical test performance characteristics between players selected into the Norwegian talent development programme, and their equal peers that are not selected. An observational study can be used as an onetime measurement of a sample of individuals, or groups to explore associations between variables, and provide an "picture" of the investigated phenomena (Setia, 2016). The independent samples t-test was chosen for analysis for its relevance of comparing two independent groups (O'Donoghue, 2012), which is the aim of this particular study. Although the observational method was deemed suitable for this research, it can only provide limited information, are subject to biases, it is difficult to derive causal relationships, and has limited generalizability due to the single point in time measurement (Setia, 2016). The results of this study should be interpreted with caution, and rather be used as conjunction with other study designs to establish causality and generalize findings (Setia, 2016).

4.2 Participants

The participants consisted of ninety-six soccer players (selected girls: $n = 14$; non-selected girls: $n = 18$; selected boys: $n = 16$; non-selected boys: $n = 48$), who all were registered members of NFF soccer clubs. Initially the pre-determined inclusion criteria were that all participants had to be born in the calendar year 2008, but due to a lack of availability of subjects, the criteria for non-selected girls were ignored. This led to a significantly higher mean age (0.7 years) of non-selected girls in comparison to the selected girls. However, the median (0.6) for age in non-selected girls were deemed low enough to present their results in comparison to the selected in the present study. In terms of sample size, the initial aim for the study was to have at least twenty subjects in each group. Due to this research being limited to only recruiting players from the local region, the number of available players to include in the selected categories are scarce. Initially a higher amount of both selected, and non-selected subject was invited to participate in the study, but for unknown reasons they could not take part in the study (most likely due to injuries or other activities with the represented club).

To generalize the results from this study, the non-selected subjects consisted of players from different teams and clubs to achieve random sampling which can be representative for the assigned population (Polit & Beck, 2010). This most likely ensured a variation in subjects training history and background, as they are divided into different environments, which in their isolated context are influenced by their separate coaching philosophies. Some coaches might have influenced the technical aspects of the game in a larger sense, whilst some might have been more focused on the physical aspects.

4.3 Sprint

Based on the literature, distances between 0 – 30 m has been deemed as an acceptable distance for testing of linear speed abilities (Haugen, Tønnessen, Hisdal, et al., 2014; Svensson & Drust, 2005; Turner et al., 2011), as most sprints occurring during match play in professional soccer are between 5 – 20 m, with positional differences in both total distance and number of sprints (Bradley & Scott, 2020; Di Salvo et al., 2009; Ingebrigtsen et al., 2015; Vigne et al., 2010). For this study the sprint test was standardized and identical for each subject, with each sprint starting from a standing start to provide accuracy to the test (Haugen & Buchheit, 2016; Turner et al., 2011). In line with recommendations, the subjects in this study performed a total of three sprints, and using the best individual split times (10, 20, 30 m) for analysis (Turner et al., 2011). The recording of split times increases the efficiency of the test, as it measures both acceleration and near maximal speed of the subjects (Turner et al., 2011). For measurement this study used dual-beamed photocells which has been proven accurate and reliable for short sprints (Haugen & Buchheit, 2016).

It is also noticeable that even though testing indoors on a synthetic sports floor eliminates certain environmental factors, all match play occurs outdoors on either natural, or artificial grass wearing soccer boots. These differences are however either small or trivial during short sprints (Haugen & Buchheit, 2016). The ecological validity between an initially standing still sprint and natural match play must be considered though, as most sprints in play are commenced through initial movement (Di Salvo et al., 2009; Svensson & Drust, 2005).

4.4 Vertical jump

During a soccer match the players must perform various explosive actions, such as linear and horizontal jumping, accelerate, decelerate, sprint, and make rapid changes of direction (Little & Williams, 2005; Ronnestad et al., 2008). These high-intensity actions require good power production of the players, which is a combination of strength and speed (Cormie et al., 2011; Ronnestad et al., 2008). Due to its prevalence in game situations, testing of players power capacities, especially in form of CMJ is widely used (Paul & Nassis, 2015; Turner et al., 2011). In addition, CMJ has shown to be a reliable and valid test when performed with the correct equipment and using a standardized protocol (Dugdale et al., 2019; Lindberg et al., 2022). In this study a force platform were used, which is seen as the gold standard for this type of measurement as it calculates the height from the velocity initiated in the vertical push off from the ground (Castagna et al., 2013; Rago et al., 2018). The subjects performed a total of three accepted attempts, and during each attempt the jump was initiated after a signal from the test personnel. During each jump the subjects were instructed to keep hands on the hips and perform a self-assessed downward movement prior to the jump.

4.5 Change of direction

The ability to change direction during high-intensity actions is considered as an integral part of soccer (Brughelli et al., 2008). During a soccer match COD is apparent in many game-related actions due to the dynamic style of the game (Bangsbo, 2014; Little & Williams, 2005), but there are also differences in the movement patterns of players based on their roles and positions in the team (Sporis et al., 2010). In this study the COD test consisted of a total of two 12.5 m linear sprints and four 180° turns with a five metres distance between them. As the ability to accelerate is often referred to being the first 10 m of a running bout (Buchheit et al., 2012; Little & Williams, 2005), it is plausible to assume that the distances in this test is highly accurate with many of the rapid movements players are exposed to during match play, as it requires them to accelerate and decelerate over varying distances. A recent study revealed that 120-180° angled turns are the most frequent in match play (Dos'Santos et al., 2022), which implies that the nature of the chosen test is highly related to soccer play. Technical impairment related to the dual-beamed photocells used in the test laboratory, single-beamed photocells had to be used for this test. It has earlier been shown that there can be absolute time differences of -0.05 to -0.06 seconds between these two devices during a normal sprint (Haugen, Tønnessen, Svendsen, et al., 2014). As single-beamed photocells are susceptible to the beam being broken twice due to inappropriate height adjustment (Haugen & Buchheit, 2016) the photocells were placed in one metre height, which is the maximal height of the standard tripod (Haugen, Tønnessen, Svendsen, et al., 2014). Though this type of test is validated for soccer specific actions (Sporis et al., 2010) it is important to consider the testing environment for this particular test, as previously discussed with the sprint test. For this test the photocells were placed by the start and end line, which only measures the total time it takes to perform the test. For future reference placement of photocells that measure split times during the 180° turns could be ideal to differentiate between turns initiated by different acceleration lengths.

4.6 Strength

With strength and power of the lower extremities being an important physical attribute for soccer players to effectively perform various movements efficiently (Cometti et al., 2001), reliable measurements of these physical abilities of athletes are important (Lindberg et al., 2022). For this study a Keiser leg press device was used to measure the participants theoretical maximal power (P_{max}), with a combined measure in watts of the right and left foot. The leg press exercise has previously proven to be a highly reliable measurement method for P_{max} (Lindberg, Eythorsdottir, et al., 2021; Lindberg, Solberg, et al., 2021), and has also been established as an acceptable test method for soccer players (Redden et al., 2018). Test personnel ensured that the seating position was adjusted to a 90° knee-angle, with feet placed with heels at the lower end of the pedal. During each repetition the participants were encouraged to extend their legs as explosively as possible. These standardized protocols contribute to the high reliability of the Keiser leg press (Lindberg, Eythorsdottir, et al., 2021). In addition, the standardized protocol makes the leg press less dependent on technique compared to other weight-based exercises, and since the movement is entirely dependent on the concentric muscle action, there is no need for an eccentric decelerating of mass during efforts (Lindberg, Eythorsdottir, et al., 2021). A limitation however might be the relevance of such an isolated movement in a seated position in comparison to a movement in a soccer match (Redden et al., 2018), where a higher degree of coordination during multi-jointed actions are required (Cometti et al., 2001).

The results of the Keiser leg press test were excluded from the final analysis as the machine used for testing in this study malfunctioned prior to the testing of both selected girls and boys. As the main objectives of this study was to compare the characteristics of the selected and non-selected groups, the decision to exclude the test results in its entity was deemed acceptable.

4.7 Testing

The use of laboratory-based testing allowed the assessment of physiological characteristics in a controlled environment, with equipment that has good reliability to ensure accurate information of the collected data (Svensson & Drust, 2005). Although laboratory tests on soccer related tests can provide us with accurate results, careful consideration is needed when interpreting these results in a game specific environment which is highly complex and situation dependant (Svensson & Drust, 2005). Although laboratory testing might be logistically challenging, it was deemed the most appropriate in the case of this study due to the chosen performance tests and equipment required (Turner et al., 2011).

All participants were told to refrain from strenuous physical activity 24 h preceding the test day to avoid possible fatigue from affecting the results (Turner et al., 2011). Practically, the present study only had the possibility to encourage them to do this, as controlling it were not possible. Each of the nine separate test days followed a similar procedure. When participants arrived for the test day, they were first gathered in a classroom where they received practical information regarding the tests and the research project. Additionally, anthropometric measurements, and registration of date of birth and playing position, and handing in the informed written consent was done. Next the participants took part in the dynamic warm-up, followed by 30-m sprint as the first test, before they were randomly allocated to either, CMJ, COD, or strength test. The order of tests in this study were slightly contradictive to recommendations (Turner et al., 2011), however, the chosen order was deemed satisfying for practical reasons. A recommended, sufficient amount of rest was ensured for each participant in subsequent repetitions, and between different performance tests (Turner et al., 2011).

In this study testing was done during a three-week period of pre-season training, which is often characterized by an increase in intensity. A previous study on male professionals revealed that during an 8-week preseason with concurrent strength an high-intensity interval training caused significant changes in physical performance, thus it plausible to believe, that changes had already occurred after 2 – 3 weeks of training (Wong et al., 2010). Another study of recreational youth players revealed that a short three-week preseason period with added strength training was enough to cause high improvements in physical performance (Koral et al., 2021). For the sake of this study, it is difficult to hypothesize whether the time between the first and last day of testing could have led to better performance in the participants who tested towards the end of the period, as the aim of this study was not to monitor training load.

A determining reason for the inclusion of the specific tests used in this study are firstly their relevance to match play (Dos'Santos et al., 2022; Faude et al., 2012; Martínez-Hernández et al., 2023), in addition to their practical relevance and usefulness (Svensson & Drust, 2005; Turner et al., 2011). Furthermore, space limitations in the test laboratory did not allow for measurement of other, soccer-specific abilities, such as the Yo-Yo intermittent test for endurance (Datson et al., 2020; Deprez et al., 2015; Emmonds et al., 2016; Forsman et al., 2016), and technical skills as dribbling and ball control (Forsman et al., 2016; Höner et al., 2017; Leyhr et al., 2020; Reilly et al., 2000) which has proven to discriminate between players of different playing level, age, and also provide prognostic value for future success. In terms of strength testing, it was impossible to predict the malfunction of test equipment in this study. However, retrospectively a 1RM back squat, or an alternative calculation based on submaximal repetitions could have been a more suitable test method, although it is technically more challenging (Paul & Nassis, 2015).

4.8 Strengths and limitations

One of the main strengths of the present study is the cross-sectional research design of which required minimal effort from the subjects, having to only partake in one-time measurement that led to no interference in terms of their daily club activities. Furthermore, studies utilizing an observational method can be conducted relatively fast, requires less resources, and are inexpensive. Additionally, the good reliability and validity of the equipment together with the selected performance tests are viewed as a strength in the present study.

Contradictive to the strengths of the present study are the limitations. A major limitation present is the observational research design that limits the possibility to derive causal relationships from the results. The present study is limited to only providing a momentary status of performance levels at the time of the test. Secondly, the subjects age group can be categorized as middle to late adolescence, thus large variation might be present in the individual's performance, as maturation contradictive to chronological age is a far more non-linear process. The evident difference in chronological age for females participating in the study most likely influenced the discriminative value between selected and non-selected, as physiological characteristics most likely still increase at this age. Thirdly, having no clear information of the subjects prior accumulated training experience, direct conclusions of the discriminative value between selected and non-selected in the performance tests can only be hypothesized as a possible result of higher motivation in selected players, which has led to superior systemized training. The fact that the synthetic floor on which the sprint and COD tests were implemented was slippery proved to be an additional limitation. Especially the decelerations during the COD test were affected by this, where some subjects clearly struggled decelerating without sliding across the floor.

Although the number of subject present in the study was deemed acceptable, interpretation and generalization of the results must be done carefully. However, as the present study was limited to one region, it is worthwhile to mention that the number of subjects that would fit the selected category is limited. Additionally, access to female participants is challenging due to a lower number of active players, and the unfortunate difference of resources spent on talent development between males and females. With performance characteristics in soccer being position specific, the relatively low number of subjects did not allow analysis comparing different player positions. Lastly, the unfortunate malfunction of the Keiser leg press machine resulted in a lower number of measured characteristics than what was desired.

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PART 2

RESEARCH PAPER

Does physical characteristics play a role when selecting youth soccer players into a talent development program?

The following paper is written in according to the standards of the following journal:

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Human Kinetics

Sampsa Lohiniva

Does physical characteristics play a role when selecting youth soccer players into a talent development program?

Original investigation

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Abstract

Background: Soccer is a complex sport that require scouts and coaches to assess a number of physical characteristics when selecting players to developmental systems. The aim of this study was to compare physiological test performance characteristics of players selected into a Norwegian talent developing program (selected) with their equal peers (non-selected).

Methods: Ninety-six soccer players divided into groups of selected and non-selected (selected girls: n = 14, mean age 14.8 ± 0.2 years; non-selected girls: n =18, mean age 15.5 ± 0.6 years; selected boys: n = 16, mean age 14.7 ± 0.3 years; non-selected boys: n = 48, mean age 14.7 ± 0.3 years) were tested for 10-, 20-, 30-m linear sprint, velocity m/s, change of direction (COD) dominant and non-dominant, and countermovement jump (CMJ) in an indoor laboratory.

Results: Independent t-test and Cohen's effect sizes (ES) were used to compare means. Group comparisons revealed trivial to large ES for 10-, 20-, 30-m sprint, velocity, CMJ, and COD dominant, and non-dominant were (0.15; -0.42; -0.35; 0.06; -0.57; -0.64; -0.43), respectively, for girls and (-0.93; -0,80; -1.04; 1.24; 0.51; -0.79; -0.78), respectively, for boys. However, only 30-m sprint and velocity showed significant difference between selected and non-selected boys.

Conclusion: Although a tendency towards better physical performance is evident in the selected players of both genders, only 30-sprint and running velocity seems to be a discriminative attribute between selected and non-selected boys. A plausible explanation for better results in selected players might be increased exposure to systematic training.

Keywords: Soccer, Talent identification, Sprint, Change of direction, Countermovement jump, Physical performance testing

Introduction

Ever since the turn of the millennium, sports scientists, and researchers have been occupied with the substantive growth of research related to talent identification and development, with a variety of studies having attempted to offer empirical evidence on the prognostic value of different characteristics, abilities, and skills of young soccer players.[1] Add to that the extensive expansion of women's soccer recently, there is an even bigger need to additionally provide empirical evidence of prognostic value contextualized for professional female soccer.[2] Providing relevant information and tools for coaches and practitioners is important to allow them to nurture young players as they progress through development stage to professional adults.[3]

The multidisciplinary nature of soccer as a sport requires players to possess a wide variety of technical/biomechanical, tactical, mental, and physiological traits, the combined level of expertise has to be balanced among these traits to ensure success, rather than isolating expertise to only some of the traits.[4] The variety of characteristics required for soccer provides challenges for coaches and scouts participating in the identification process, which often rely on the evaluation of players current, rather than future performance.[1,5] As young soccer players dynamically mature and develop at different rates, possess unique learning abilities, and gain diverse experience, a continuous assessment of characteristics crucial for expertise throughout the developmental years is important.[5]

It is of our knowledge that powerful anaerobic bouts are important contributors to goals scored in professional soccer.[6] Additionally, physical demands of professional soccer, especially in terms of high intensity running and sprinting continues to increase,[7] hence why the relevance of investigating these attributes are important.[5] Previous studies assessing motor performance have established speed, COD, and power to be distinct characteristics that discriminate between selected and non-selected players,[8-11] thus providing evidence for relevant physical attributes to assess in physical performance tests.[5] With soccer being a sport that consists of repeated short sprints, rapid accelerations and decelerations, changes of direction, and jumping, it comes as no surprise that specific motor performances are decisive as the professional game concurrently become physically and technically more demanding.[12] During a soccer game the activity profiles for male and female players consists of roughly ~1300 of these mainly brief locomotor activities, of which many are explosive of nature.[2,4]

With large participation rates, associations, and clubs (local and elite) do not necessarily have sufficient resources to nurture all the players taking part in soccer, thus early talent selection is a necessity to provide adequate development programs for talented players. In context of this study, selection of talented players to the Norwegian talent developing program is solely based on coaches' subjective[13] evaluation of players. Although certain criteria's are present during evaluation, often the outcome of it is reliant on the coaches innate image of important attributes the player has to possess.[13] Thus, evaluation of influential physical attributes provides objective relevance to the otherwise subjective evaluation of players[1,13] Furthermore, as speed, COD, and power are determinants of success,[6,14] monitoring these abilities during development are important due to their prognostic value.[1] With the increased focus on physical performance in modern soccer, the present study aims to examine the potential differences in physical test performance of youth soccer players selected into a talent development program and their non-selected peers within both male and female players.

Methods

Subjects

Ninety-six players completed the physical performance tests (Selected girls: n = 14; Non-selected girls: n =18; Selected boys: n = 16; Non-selected boys: n = 48). However, goalkeepers (n = 1 selected girl; n = 2 non-selected girls; n = 4 selected boys; n = 4 non-selected boys) were excluded from sprint tests due to differences in positional demands.[4] Furthermore (n = 1 selected girl; n = 3 non-selected boys) players were excluded from the COD analysis due to failing to register valid test results. Written informed consent was obtained from all players and their guardians before the study commenced. The study was carried out according to the Declaration of Helsinki and approved by the Ethics Committee of the Faculty for Health and Sports Science, University of Agder, Kristiansand, Norway.

Design

The present study was cross-sectional research comparing physical test performance characteristics of selected and non-selected youth players. All the players were playing for different local U15 teams in the region. Additionally, some of these players are annually selected to be part of a regional team under the Norwegian talent development program, categorized as selected players in this study. Selected players were recruited through the regional team and being a part of the team at the time of testing was a prerequisite, with the non-selected peers being recruited through their respective club and U15 team. Testing was performed at the lab facilities of the University of Agder, Norway. All data were collected within a three-week period during the 2023 pre-season phase.

Testing Procedures

Participants were in advance encouraged to refrain from strenuous exercise 24 hours prior to testing. All tests were performed on the same time of day, with the same equipment in a controlled indoor environment, overseen by the same trained instructors. Prior to the physical performance tests, the participants measured their height and weight and took part in a 10-min warm-up consisting of dynamic movement and stretching. The following physical tests and measurements were carried out in one test session: anthropometry (height, weight), date of birth, 30-m sprint, CMJ, and COD test. All participants carried out the 30-m sprint test initially, before being randomly allocated to either CMJ, or COD test.

30-m sprint

All participants performed three maximal 30-m sprints on an even indoor sports floor with a synthetic surface, separated by a three-minute recovery between each sprint to ensure sufficient recovery between each sprint. Time was measured with dual beamed photocells (MuscleLab 20, version 10.201.93.0, Ergotest, Norway) placed with 10-m intervals to measure time between distances (i.e., 0 – 10, 10 – 20 and 20 – 30-m.). Each sprint started from a standing position with the leading foot slightly behind the first timing gate. Each participant was verbally instructed to sprint as fast as possible past the furthest timing gate. The best single 30-m attempt together with best 10-m and 20-m splits were retained for analysis. Maximal speed was calculated from the best 20 – 30-m split time.

CMJ

Maximal vertical jumping ability were performed using a portable force platform (AMTI, Advanced Mechanical Technology Inc, USA). Participants performed three jumps interspersed with approximately 30-second rest between each jump. Each jump was performed with hands kept on the hips and participants were instructed to perform a self-assessed downward movement followed by a maximal vertical jump [15]. The best jump attempt measured in centimetres was retained for analysis.

COD

COD were measured using the OLT40 agility test. The test consists of a 12.5-m linear sprint, followed up by four right or left 180° turns with 5-m distance in between them, finished off with another 12.5-m linear sprint to the end line (total distance 40-m). The starting position was the same as for the sprint test. All the turns had to be made with the same foot and had to cross the lines. Being in contact with a line during any of the turns would lead to a failed attempt. Time was measured with TCi system (Brower Timing System, USA). The participants performed two attempts with both right and left foot, with a total of four attempts, separated by a three-minute recovery between each attempt. The best attempt of both feet was retained for analysis. The OLT40 agility test setup is illustrated in Figure 1.

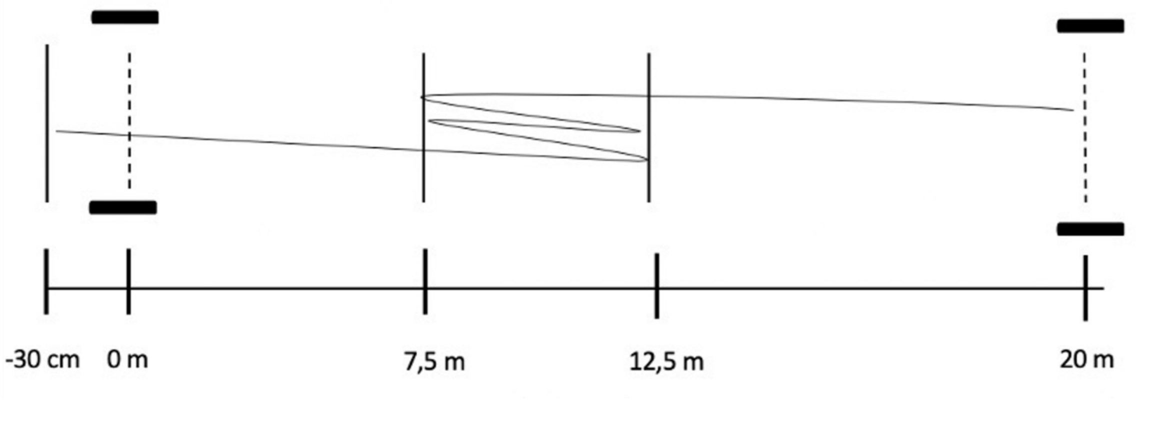

FIGURE 1 | Illustration of the OLT40 agility test

Statistical Analysis

All statistical analyses were performed using the SPSS (Version 28.0. Armonk, NY: IBM Corp) and Microsoft Excel. Normal distribution was confirmed using Q-Q plots, Shapiro-Wilk test, and visual inspection of variable histogram. Data are presented as mean ± standard deviation (SD) and 95% CI. Independent samples t-test were used to investigate differences between selected and non-selected players of both genders. Cohen's *d* ES with effect size <0.2, 0.2 – 0.6, 0.6 – 1.2, 1.2 – 2.0, and >2.0 considered trivial, small, moderate, large, very large and extremely large, respectively, were used to compare the magnitude of the differences between selected and non-selected. The level of significance was set at $p < 0.05$ for all statistical analyses.

Results

Participants age and anthropometric results are presented in Table 1. No statistically significant differences were found between the compared groups, with only trivial to small ES observed, with the only exception being the selected girls age, who were statistically different from the non-selected girls with a negatively very large ES.

Table 1 | Age and anthropometric results of selected and non-selected soccer players of both genders

	Girls				**Boys**			
	Selected (n=14)	**Non-Selected (n=18)**	**ES**	**95% CI**	**Selected (n=16)**	**Non-Selected (n=48)**	**ES**	**95% CI**
Age (yrs)	14.8 ± 0.2*	15.5 ± 0.6	-1.44	-1.00/-0.36	14.7 ± 0.3	14.7 ± 0.3	-0.05	-0.18/0.15
BW (kg)	57.1 ± 8.8	60.3 ± 8.7	-0.37	-9.61/3.12	62.4 ± 7.7	60.3 ± 9.3	0.23	-3.08/7.23
Height (cm)	165.4 ± 4.3	167.1 ± 6.2	-0.31	-5.62/2.28	176.8 ± 6.5	172.4 ± 8.2	0.56	-0.15/8.88

Values are presented in mean ± SD. Yrs: years, BW: bodyweight, kg: kilograms, cm: centimetres
* Statistically different ($p < 0.001$) from non-selected girls

Participants physiological test results are presented in Table 2. No statistically significant differences were found between the compared groups, apart from selected and non-selected boys for the variables 30-m sprint (p <0.05) and peak velocity m/s (p <0.001). Out of the seven physiological variables the ES between selected and non-selected girls were trivial for 10-m sprint and velocity, small for 20-m, 30-m sprint, CMJ, and COD non-dominant, and moderate for COD dominant. For selected and non-selected boys CMJ were small, 10-m, 20-m, 30-m sprint, COD dominant, and non-dominant moderate, while velocity was moderate to large. Figure 2 presents the distribution of data in the eight physiological variables for each of the selected, and non-selected groups with individual plots for each measurement.

Table 2 | Physiological test results of selected and non-selected soccer players of both genders

	Girls				**Boys**			
	Selected	**Non-Selected**	**ES**	**95% CI**	**Selected**	**Non-Selected**	**ES**	**95% CI**
10 m (s)	1.84 ± 0.09 (n = 13)	1.82 ± 0.15 (n = 16)	0.15	-0.80/0.12	1.62 ± 0.13 (n = 12)	1.73 ± 0.12 (n = 44)	-0.93	-0.20/-0.03
20 m (s)	3.30 ± 0.22 (n = 13)	3.38 ± 0.18 (n = 16)	-0.42	-0.24/0.07	2.97 ± 0.15 (n = 12)	3.15 ± 0.23 (n = 44)	-0.80	-0.32/-0.03
30 m (s)	4.79 ± 0.17 (n = 13)	4.86 ± 0.24 (n = 16)	-0.35	-0.24/0.09	4.23 ± 0.20# (n = 12)	4.53 ± 0.31 (n = 44)	-1.04	-0.49/-0.11
Velocity (m/s)	6.81 ± 0.68 (n = 13)	6.78 ± 0.33 (n = 16)	0.06	-0.37/0.43	7.97 ± 0.43* (n = 12)	7.29 ± 0.58 (n = 44)	1.24	0.32/1.04
CMJ (cm)	23.4 ± 2.6 (n = 14)	24.6 ± 3.0 (n = 18)	-0.57	-3.33/0.86	30.4 ± 4.8 (n = 16)	27.7 ± 5.5 (n = 48)	0.51	-0.38/5.75
COD dom. (s)	11.30 ± 0.39 (n = 14)	11.65 ± 0.65 (n = 18)	-0.64	-0.76/0.05	10.60 ± 0.59 (n = 16)	11.23 ± 0.84 (n = 47)	-0.79	-1.09/-0.17
COD non-dom (s)	11.19 ± 0.52 (n = 13)	11.48 ± 0.49 (n = 18)	-0.43	-0.66/0.09	10.57 ± 0.5 (n = 16)	11.19 ± 0.86 (n = 46)	-0.78	-1.08/-0.17

Values are presented in mean ± SD. M, metres; S, seconds; M/S, metres per second; CMJ, countermovement jump; CM, centimetres; COD, change of direction; DOM., dominant; NON-DOM, non-dominant

* Statistically different (p < 0.001) from non-selected boys

Statistically different (p < 0.05) from non-selected boys

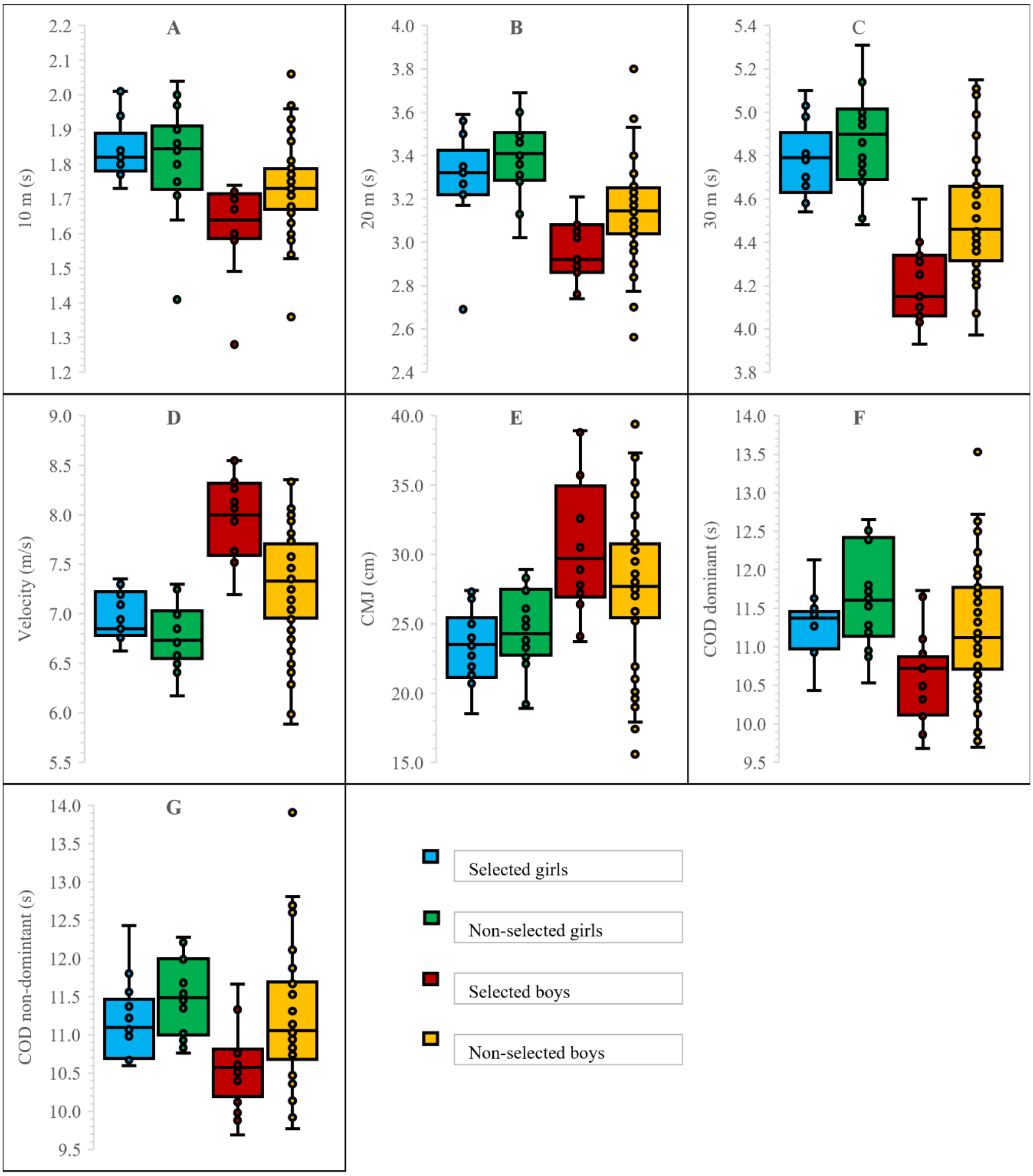

FIGURE 2 | Variation of differences in the physiological tests between selected girls (blue), de-selected girls (green), selected boys (red) and de-selected boys (orange). Data are presented as mean ± SD and individual plots for each variable. **(A)** 10 m sprint, **(B)** 20 m sprint, **(C)** 30 m sprint, **(D)** Maximal velocity, **(E)** Countermovement jump, **(F)** Change of direction dominant, **(G)** Change of direction non-dominant. M, metres; S, seconds; M/S, metres per second; CMJ, countermovement jump; CM, centimetres; COD, change of direction; DOM., dominant; NON-DOM., non-dominant

Discussion

The aim of the present study was to examine potential differences in physical test performance of youth soccer players selected into a talent development program and their non-selected peers within both male and female players. The main findings of this research study were, that for boys 30-m sprint and peak velocity seems to offer most discriminative value for selected boys, while 10-, 20-m sprint, COD and jumping ability only showing tendency with small to moderate evidence of discriminative value. Respectively, for selected girls in the present study, physical performance tests only offer trivial to small discriminative value. In line with previous research,[8,10,11,16-20] this present study managed to reveal a tendency towards differences in performance tests of physiological characteristics of selected and non-selected youth players. Albeit only on significant level for the variables 30-m sprint and peak running velocity for boys. Previous research on physiological characteristics presents a variety of discriminative value of different performance factors. Across the same age group, some have only found small discriminative value in males and females for sprinting,[8,10,16,19,21] jumping,[8,19-22] and COD for boys.[10,21,23] Other studies have reported more distinct values of performance in boys and girls for sprinting,[9,18,23-26] COD,[9,18,24,26] and jumping for boys.[23,24,26] Similar results were found by researchers investigating the same performance characteristics, albeit older players in their late adolescence.[11,27]

The results for sprint distances for boys in this present study are generally superior to those of earlier studies, which have reported sprint times of players of the same age,[8,10,17,24] while some studies have reported better sprint results than this present study.[18,20] Comparison of the girl's results revealed that they were faster than a study of Spanish players,[28] but slower than English players[19] of relatively same age. Along with previous studies[8-10,16,18,19] that compared youth players of different performance levels, the present study offers similar discriminative value of speed abilities for selected players. Comparing the jump results with previous research of similar age groups revealed that the discriminative value in favour of selected boys in the present study were similar to that of previous studies.[8,20,22] In the present study no discriminative value was found in jumping for girls, with non-selected actually outperforming their selected peers. Along with previous studies,[9,10,18,21,23,24,26] discriminative value were found for selected boys and girls in COD in the present study, although the extent of its discriminative value is somewhat lower in comparison. Comparison of COD across the literature is challenging due to a lack of consensus regarding test methods, where large amount of tests with varying distances and turns are present,[29] which is also the case for the aforementioned studies that have measured COD. However, the relevance of the specific COD test used in the present study was deemed influential for measuring match performance, as it included several 180° turns in quick succession, which simulates the most occurring turns in professional soccer.[14]

It is of interest to see, that the physical performance tests in the present study seem to offer more discriminative value male players than female players. For comparison speed abilities of male players offer the most discriminative relevance, whereas COD presents the most for female players, indicating that distinct abilities potentially might offer discriminative value between male and female players. It is however important to consider the age difference between the female groups in the present study, and how that might influence the obtained results. Previously it has been suggested that females sprint and COD improve the most up to age 13, whereas CMJ improves until 15-16 years of age,[30] which might explain CMJ results in the present study. With that in mind, it is plausible to suggest that with no age difference between the groups the discriminative value of performance tests would have favoured the selected female players in line with their male peers, and been in line with previous literature which have stated similar performance tests to be generalizable independent of sex.[9] Furthermore, omission of endurance testing (YoYo IR1) might have led to an overall lack of discriminative value between groups in the present study, as high-intensity endurance capacity has shown to have predictive value for future success in both males and females.[11,16,19,23]

The differences of reported discriminative value for physiological characteristics across existing empirical evidence contributes to the difficulty in generalizing evidence. Firstly, a clear explanation of player level is not always evident in the research, and different classifications of levels are present. One possible explanation is the variation of sport development pathways in different countries. A second explanation might be, that some countries possess a higher number of elite academies that recruit players at a young age to influence their specialized sports development path. Thirdly, these separate academies employ different strategies based on their methodology, which in turn can influence the development of individuals differently.[13] Furthermore, studies utilize different equipment and modified test protocols for measurement which might directly influence the outcome of results, hence making direct comparison difficult.[31,32] In the present study the outcome of discriminative values might have been influenced by the homogeneity of the compared groups, as selected players belonging to regional teams are still members of local clubs, where they partake in the same training and match environment as their non-selected peers. Additionally, selected players partake in separate training and matches directed by the Norwegian development system.

In contrast to many other countries, the Norwegian development system is based around local sport clubs, where athletes practice and play in the same environment. Coaches working in these sport clubs are mostly voluntary, with varying experience or formal education or expertise in coaching. Yet, there are elite clubs that have their own talent recruitment, but the number of players that can take part in these are scarce, with limited resources available in the clubs to provide adequate coaching staff. Additionally, a national team development program (12 – 16 years) with the aim of identifying players with the highest future potential are present. They particularly highlight the value of players technical and perceptual-cognitive skills, while trainability, coping, presence, and achievement motivation are valued personality traits.[33] Considering the combined discriminative value of physiological abilities in the present study, it is plausible to believe that during the selection process of the selected players, the aforementioned skills and traits have received greater value over physiological. Yet, physical characteristics (power, and linear and multidirectional speed) which influence game situations (i.e., running, jumping, tackling, and finishing) are critical in defining moments during a game, and may influence the selection process.[6,12]

A limitation in the present study is the influence of maturity on performance, which was not measured. Selection in the Norwegian context are based on the calendar year that they are born, rather than their maturity status. Another limitation is the nature of the study design applied in the present study. Measurement was only done at one point, whereas a longitudinal design would have provided better understanding of the development of performance, when confounding maturation status is absent. The relatively low sample size and the geographical limitation of tested players in the present study directly affects generalization of the results. In addition, low sample size hindered assessment of positional differences which would have been relevant.[25] Furthermore, soccer is a multidimensional, complex construct that requires an extension of talent indicators,[1] thus limiting the overall value of the present study. Evaluation of other sport-specific skills, such as technical ability which has prognostic value were not examined in the present study.[9-11,27]

Practical Applications
Although the physical performance tests in this study provides some discriminative value for physiological characteristics for boys, extending them to contextualize in match related performance is of importance. Physiological traits manifest themselves differently across playing positions and based on situation-specific actions in defensive, and offensive play. Contradictive to previous empirical evidence that physical performance tests are generalisable independent of sex to differentiate between playing levels,[9] the present study provides no discriminative value for physiological characteristics in girls of different playing level. Most likely due to the age difference of compared groups,[30] albeit a tendency towards better performance in the selected girls are evident. Furthermore, this study provides coaches and practitioners additional insight on motor performance characteristics as potential talent predictors. However, coaches and practitioners should be relying on a holistic approach in talent identification and be cautious of physical biases when selecting players. The perspective should be longitudinal, allowing later maturing players to reach motor performance levels of earlier maturing peers all the while benefiting from their "overcompensation phenomenon". Development through adolescence is a dynamic process influenced by several factors, hence why consideration of the multidimensional aspects of soccer performance and development is important. Although subjective evaluation is a strong, independent tool in talent identification, it is recommended that objective assessment of motor performance is applied simultaneously in order to further strengthen the evaluation process.[13] Additionally this study provides coaches and practitioners insight on which physiological characteristics could be used to monitor and evaluate player development by utilizing performance tests in an objective manner. Future research should focus more on identifying factors that influence future performance in a holistic perspective, especially for female players.

Conclusion
The present study provides empirical evidence of differences in physical performance between selected and non-selected youth soccer players. The discriminative value of these attributes is more evident in male players, with speed abilities being the most discriminating, whereas for female players, no obvious evidence for discriminative value is evident.

Acknowledgments
The present study was conducted in collaboration with the University of Agder. The author(s) would like to thank all the players for their participation in the study. Author(s) would also like to express our gratitude to the test personnel contributing to the data collection.

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PART 3

APPENDICES

Contents:

Appendix 1 – Informed consent form

Vil du delta i forskningsprosjektet

"Fysiologiske karakteristika av unge fotballspillere i Norge"?

Hei! Har du lyst å være med i et forskningsprosjekt? Vi ønsker å vite mer om fysiologiske karakteristika av unge fotballspillere på ulikt nivå.

Formål
Formålet med prosjektet er å undersøke hvilke fysiologiske egenskaper som mulig er viktige for unge fotballspillere.
Vi ønsker gjerne å rekruttere både jenter og gutter i 14-16 års alderen som er aktive medlemmer i lokale idrettslag-/klubber. Vi håper du vil være med!

Som deltaker i prosjektet vil du blant annet:

- *Ta del i et testbatteri som gjennomføres på Olympiatoppen sine lokaler på Spicheren. Dette er enkle fysiologiske tester som Du som deltaker vil få nærmere innføring i. Disse testene består av en 30 meter sprint, vertikalt hopp (motbevegelse), kort retningsforandringsøvelse, samt en beinpress øvelse for å måle kraftproduksjon.*
- *I tillegg til ovennevnte fysiologiske tester, vil Du som deltaker også måle høyde, vekt, og oppgi din fødselsdato.*

Som deltaker er det også viktig, at Du som deltaker er klar over eventuelle ulemper ved deltakelse i studiet. De fysiske testene innebærer risikoen for mulig oppstått skade, men som deltaker vil Du få en grundig gjennomgang av testprotokollen, samt hvilke tiltak som gjøres for å minimere mulige skader.

Hvis du har lyst å være med, vil vi gjerne også ha skriftlig samtykke av dine foresatte dersom du er under 16 år.

Dette prosjektet er et forskningsprosjekt fra Fakultet for helse- og Idrettsvitenskap ved Universitetet i Agder.

Hvem leder forskningsprosjektet?
Prosjektet er tilknyttet forskningsgruppen Sports Performance and Athlete Development (SPADE) ved institutt for idrettsvitenskap og kroppsøving ved Universitetet i Agder. Postdoktor Martin Kjeøen Erikstad og stipendiat Per Thomas Byrkjedal ved Institutt for idrettsvitenskap og kroppsøving ved Universitetet i Agder er ansvarlig for prosjektet.

Masterstudent Sampsa Lohiniva har ansvaret for kontakten med deltakerne og gjennomføringen av prosjektet.

Hvorfor får du spørsmål om å delta?
Vi spør deg om å være med, fordi du er aktivt medlem i idrettslag-/klubb og i en aldersgruppe som passer utvalget i aldersgruppen 14-16 år.

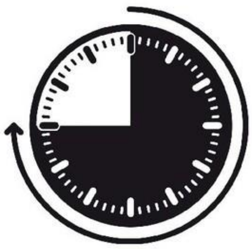
Vi vet enda ikke hvem du er eller hva du heter, men din kontaktperson klubb gir deg dette brevet fra oss.

Hvis du har lyst å være med i forskningsprosjektet, må du skrive under på siste ark i dette brevet, og da vil vi ta kontakt med deg.

Hvis du ikke har lyst å være med, tar vi ikke kontakt med deg.

Hva betyr det for deg å delta?
Hvis du har lyst å delta i forskningsprosjektet, kommer du til å bli nærmere kontaktet angående nærmere orientasjon for hvordan testen du skal delta i skal gjennomføres.

Sampsa Lohiniva vil være med under testene, samt ved veiledning av testprotokoller. Veiledning og testing vil kreve at Du deltar på en test dag med forventet omfang på 2-3 timer.



Hvis du synes det er greit, vil vi også samle inn din fødselsdato, høyde og vekt. Vekt kan måles skjermet, dvs. du har mulighet til å la være å se svaret om ønskelig.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Det betyr at du kan velge selv om du har lyst å være med eller ikke. Ingen andre kan velge dette for deg. Det er bare du som kan samtykke. Samtykke betyr at du sier at du synes noe er greit.

Hvis du vil delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Det betyr at det er lov å ombestemme seg, og det er helt i orden. All informasjon om deg vil da bli slettet.

Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller om du først sier «ja» og så «nei». Ingen vil bli sur eller lei seg, og det vil ikke ha noe å si for jobben din.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke informasjonen om deg til å finne ut om hvilke fysiologiske egenskaper som er viktige for unge fotballspillere.
Vi vil ikke dele din informasjon med andre. Det er bare forsker Sampsa Lohiniva og veileder Per Thomas Byrkjedal og medveileder Martin Kjeøen Erikstad som har tilgang til informasjonen.
Vi passer på at ingen kan få tak i informasjonen som vi samler inn om deg.
Vi lagrer all informasjon i form av et id-nr., der kun en dekoblingsnøkkel kan vise hvem som har hvilken id. Kodenøkkel oppbevares i låst safe på kontor på UiA. Kodenøkkelen destrueres ved prosjektslutt.
Vi passer på at ingen kan kjenne deg igjen når vi skriver forskningsartikler. Vi vil for eksempel finne opp et annet navn når vi skriver om deg.
Vi følger loven om personvern.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Vi er ferdig med forskningsprosjektet 31.05.2023.
All informasjon om deg lagres anonymt.

Dine rettigheter
Hvis det kommer frem opplysninger om deg i det som vi skriver, eller har i dokumentene våre, har du rett til å få se hvilken informasjon om deg som vi samler inn. Du kan også be om at informasjonen slettes slik at den ikke finnes lenger. Det som det er noen opplysninger som er feil kan du si ifra og be forskeren rette dem. Du kan også spørre om å få en kopi av få informasjonen av oss. Du kan også klage til Datatilsynet dersom du synes at vi har behandlet opplysningene om deg på en uforsiktig måte eller på en måte som ikke er riktig.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler informasjon om deg bare hvis du sier at det er greit og du skriver under på samtykkeskjemaet.

Hvor kan jeg finne ut mer?

Hvis du har spørsmål om studien, kan du ta kontakt med:

- Institutt for idrettsvitenskap og kroppsøving ved:
- Per Thomas Byrkjedal, e-post: per.byrkjedal@uia.no, tlf: 381 42 228
- Martin Kjeøen Erikstad, e-post: martin.erikstad@uia.no, tlf: 381 14 14 32
- Sampsa Lohiniva, e-post: sampsapl@student.uia.no, tlf: 978 56 553
- Vårt personvernombud: Trond Hauso, e-post: personvernombud@uia.no

Institutt for idrettsvitenskap og kroppsøving har bedt Personverntjenester se om prosjektet følger loven om personvern.

Hvis du lurer på hvorfor Personverntjenester mener dette, kan du ta kontakt med:

- Personverntjenester på epost (personverntjenester@sikt.no) eller på telefon: 53 21 15 00.

Med vennlig hilsen

Sampsa Lohiniva
Masterstudent

Fakultet for Helse- og Idrettsvitenskap
Institutt for idrettsvitenskap og kroppsøving
Universitetet i Agder
Mob: +47 97856553

UiA Institutt for idrettsvitenskap og kroppsøving

Samtykke til deltakelse i studien
For at vi skal kunne gjennomføre datainnsamlingen trenger vi samtykke av foreldre/foresatte til deltakere under 16 år.

☐ Jeg har mottatt og forstått informasjonen om prosjektet, og samtykker til deltakelse i prosjektet

☐ Jeg godtar at mine opplysninger behandles frem til prosjektet er avsluttet 31.05.2023

(Signatur foreldre/foresatte, dato)

(Fullt navn foreldre/foresatte i blokkbokstaver)

(Signatur deltaker, dato)

(Fullt navn deltaker i blokkbokstaver)

Appendix 2 – Sikt project approval

Sikt

Vurdering av behandling av personopplysninger

Referansenummer	Vurderingstype	Dato
520969	Standard	16.09.2022

Prosjekttittel
Physiological characteristics of players selected and de-selected into the Norwegian talent development program

Behandlingsansvarlig institusjon
Universitetet i Agder / Fakultet for helse- og idrettsvitenskap / Institutt for idrettsvitenskap og kroppsøving

Prosjektansvarlig
Per Thomas Byrkjedal

Student
Sampsa Pietari Lohiniva

Prosjektperiode
01.08.2022 - 31.05.2023

Kategorier personopplysninger
Alminnelige
Særlige

Lovlig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)
Uttrykkelig samtykke (Personvernforordningen art. 9 nr. 2 bokstav a)

Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet. Det lovlige grunnlaget gjelder til 31.05.2023.

Meldeskjema

Kommentar
OM VURDERINGEN
Personverntjenester har en avtale med institusjonen du forsker eller studerer ved. Denne avtalen innebærer at vi skal gi deg råd slik at behandlingen av personopplysninger i prosjektet ditt er lovlig etter personvernregelverket.

Personverntjenester har nå vurdert den planlagte behandlingen av personopplysninger. Vår vurdering er at behandlingen er lovlig, hvis den gjennomføres slik den er beskrevet i meldeskjemaet med dialog og vedlegg.

Personverntjenester i Sikt gjør ikke en etisk vurdering av prosjektet. Det fremgår at prosjektet skal sendes fakultetets etiske komité (FEK) ved UiA for vurdering. Vår vurdering forutsetter at FEK godkjenner prosjektet. Dersom FEK i sin vurdering stiller krav som har betydning for vår vurdering/personvernet, må vi få tilbakemelding.

VIKTIG INFORMASJON TIL DEG
Du må lagre, sende og sikre dataene i tråd med retningslinjene til din institusjon. Dette betyr at du må bruke leverandører for spørreskjema, skylagring, videosamtale o.l. som institusjonen din har avtale med. Vi gir generelle råd rundt dette, men det er institusjonens egne retningslinjer for informasjonssikkerhet som gjelder.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige personopplysninger, og særlige kategorier av personopplysninger om helseopplysninger frem til 31.05.2023.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Prosjektet vil innhente samtykke fra de foresatte til behandlingen av personopplysninger om barna under 16 år. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 nr. 11 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse, som kan dokumenteres, og som den registrerte kan trekke tilbake.

For alminnelige personopplysninger vil lovlig grunnlag for behandlingen være den registrertes/foresattes samtykke, jf. personvernforordningen art. 6 nr. 1 a.

Behandlingen av særlige kategorier av personopplysninger er basert på uttrykkelig samtykke fra den registrerte/foresatte, jf. personvernforordningen art. 6 nr. 1 a og art. 9 nr. 2 a.

PERSONVERNPRINSIPPER
Personverntjenester vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen:

- om lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker tilbehandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikkeviderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet medprosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet.

DE REGISTRERTES RETTIGHETER
Vi vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18) og dataportabilitet (art. 20).

Vi minner om at hvis en registrert/foresatt tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
Personverntjenester legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Ved bruk av databehandler (spørreskjemaleverandør, skylagring eller videosamtale) må behandlingen oppfylle kravene til bruk av databehandler, jf. art 28 og 29. Bruk leverandører som din institusjon har avtale med.

For å forsikre dere om at kravene oppfylles, må prosjektansvarlig følge interne retningslinjer/rådføre dere med behandlingsansvarlig institusjon.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til oss ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilken type endringer det er nødvendig å melde: https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema
Du må vente på svar fra oss før endringen gjennomføres.

OPPFØLGING AV PROSJEKTET
Vi vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Kontaktperson hos oss: Sturla Herfindal Lykke til med prosjektet!

Appendix 3 – FEK project approval

Sampsa Pietari
Lohiniva

Besøksadresse:
Universitetsveien 25
Kristiansand

Ref: [object Object]

Tidspunkt for godkjenning: : 20/09/2022

Søknad om etisk godkjenning av forskningsprosjekt - Fysiologiske karakteristika av spillere valgt inn i det Norske talentprogrammet

Vi informerer om at din søknad er ferdig behandlet og godkjent.

Kommentar fra godkjenner:
FEK godkjenner prosjektet under forutsetning av at prosjektet gjennomføres som beskrevet i søknaden.

Hilsen
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