Athlete profile: Basic anthropometry, physical fitness and specific skill of the Icelandic female youth national teams

- A descriptive analysis

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Abstract

The objective of this cross-sectional analysis was to evaluate the basic anthropometry, physical fitness and specific skill of the Icelandic youth female national teams (U-16, U-17, U-19) by playing position and age. Data were collected from 85 players over a three month period from November 2017 to February 2018. Players were categorized into five different playing positions (goalkeepers, central defenders, wingbacks, central midfielders and forwards) and assessed for basic anthropometry (height and weight), extension leg power (countermovement jump, modified Abalakov jump and 30 m sprint), agility (the Illinois Agility test), anaerobic and aerobic endurance (5 x 30 m repeated agility test, Yo-Yo intermittent endurance test level 2) and kicking velocity. Statistical analysis was performed using one-way ANOVA and standard linear regression analysis. The main findings of this descriptive analysis by playing position revealed differences in anthropometry and physical fitness. Goalkeepers were taller and had higher body mass than all other playing positions except central defenders. Differences were also found between goalkeepers and outfield players in fatigue index and YoYo IE2 performance. No differences were observed in physical fitness between outfield playing positions, except for 30 m sprints, where central midfielders were slower than wingbacks. Results by age show a positive correlation between older age, kicking velocity and performance in YoYo IE2 test. Future research should adjust assessment methods to enhance direct comparability of data and assess players development with older age in a longitudinal study.

Keywords: Football – Soccer – Youth – Female – Elite – Anthropometry – Physical fitness – Specific skill – Playing position – Age
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# Table of content

Abstract ............................................................................................................................................. 2
Acknowledgments ............................................................................................................................. 3
List of figures ........................................................................................................................................ 6
List of tables ......................................................................................................................................... 7
List of abbreviations .......................................................................................................................... 8
Introduction.......................................................................................................................................... 9
  1. Theoretical background .................................................................................................................. 10
      1.1 Physical demands of match play in female elite football ......................................................... 10
      1.2 Physical fitness of female elite football players ........................................................................ 11
      1.3 Power in female football ........................................................................................................... 13
      1.4 Endurance ................................................................................................................................ 20
      1.5 Specific skill ............................................................................................................................... 26
      1.6 Summary ................................................................................................................................... 27
  2. Methods .......................................................................................................................................... 30
      2.1 Study design ............................................................................................................................... 30
      2.1.1 Testing variables .................................................................................................................... 30
      2.2 Participants ............................................................................................................................... 31
      2.3 Procedure and materials .......................................................................................................... 33
          2.3.1 Location and testing frequency ......................................................................................... 33
          2.3.2 Inclusion criteria for data analysis .................................................................................... 33
          2.3.3 Ethical considerations ....................................................................................................... 34
      2.4 Test battery and testing procedure ........................................................................................... 35
          2.4.1 Test-session set up .............................................................................................................. 35
      2.5 Basic anthropometry .................................................................................................................. 37
          2.5.1 Height, weight and body mass index (BMI) ....................................................................... 37
      2.6 Physical fitness ........................................................................................................................... 37
          2.6.1 Power .................................................................................................................................. 37
          2.6.2 Agility .................................................................................................................................. 40
          2.6.3 Anaerobic and aerobic (Capacity and Power) .................................................................... 42
              2.6.3.1 5 x 30 meter repeated sprinting ability ....................................................................... 42


List of figures

Figure 1 – Order of tests and test session set-up.................................................................36
Figure 2 – Setup for the Countermovement jump test and Kinovea video analysis.............38
Figure 3 – Setup for the modified Abalakov jump test and Kinovea video analysis.............40
Figure 4 – Setup of the Illinois Agility test........................................................................41
Figure 5 – Setup of the 5 x 30 m repeated sprint ability test.............................................43
Figure 6 – Setup of the Yo-Yo Intermittent Endurance test level 2.....................................44
Figure 7 – Setup of the Kicking velocity test.......................................................................45
Figure 8 – The correlation between distance covered (m) in the YoYo IE2 and age.............50
Figure 9 – The correlation between right leg kicking velocity and age...............................51
Figure 10 – The correlation between left leg kicking velocity and age...............................51
List of tables

Table 1 – Basic anthropometry, physical fitness, and specific skill by playing position.................29
Table 2 – Basic anthropometry, physical fitness, and specific skill by playing position.................29
Table 3 – Variables and their measurement units.................................................................32
Table 4 – Number of participants and their birth year..........................................................32
Table 5 – Detailed participation in testing sessions by national teams....................................33
Table 6 – Dates of testing sessions by national teams..........................................................34
Table 7 – Test categories and specific tests used in this study.............................................35
Table 8 – Anthropometric and physical parameter according to playing position...............49
## List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UEFA</td>
<td>The Union of European Football Associations</td>
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<td>FIFA</td>
<td>The Fédération Internationale de Football Association</td>
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<tr>
<td>FA</td>
<td>Football association</td>
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<tr>
<td>KSÍ</td>
<td>Knattspyrnusamband Íslands</td>
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<tr>
<td>GK</td>
<td>Goalkeeper</td>
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<td>CD</td>
<td>Central defender</td>
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<td>FB</td>
<td>Fullback</td>
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<td>CM</td>
<td>Central midfielder</td>
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<td>WM</td>
<td>Wide midfielder</td>
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<td>F</td>
<td>Forward</td>
</tr>
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<td>BMI</td>
<td>Body mass index</td>
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<td>CMJ</td>
<td>Countermovement jump</td>
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<tr>
<td>COD</td>
<td>Change of direction</td>
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<tr>
<td>D</td>
<td>Defender</td>
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<tr>
<td>M</td>
<td>Midfielder</td>
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<td>F</td>
<td>Forward</td>
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<tr>
<td>HIR</td>
<td>High intensity running</td>
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<td>HSR</td>
<td>High speed running</td>
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<tr>
<td>YoYo IR1</td>
<td>Yo-Yo Intermittent recovery test level 1</td>
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<tr>
<td>YoYo IR2</td>
<td>Yo-Yo Intermittent recovery test level 2</td>
</tr>
<tr>
<td>YoYo IE2</td>
<td>Yo-Yo Intermittent endurance test level 2</td>
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<tr>
<td>RSB</td>
<td>Repeated sprint bouts</td>
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<tr>
<td>RSA</td>
<td>Repeated sprint ability</td>
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<tr>
<td>ATP</td>
<td>Adenosine triphosphate</td>
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<tr>
<td>CP</td>
<td>Creatine phosphate</td>
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Introduction

In Europe, women’s football increases in popularity every year. Most recent count from UEFA reports that 1.365.524 female players were registered within the 55 UEFA associations in June 2017, an increase of 7.5% since 2016. In concordance with increased popularity, budget within the UEFA associations rises. The overall budget for women’s football has increased annually, from 50.4 million euros in 2011 to 111.7 million euros in 2017. The number of professional and semi-professional players continues to rise as well, from 1.680 players in 2013 to 3.572 in 2017 (UEFA, 2016). The growth of women’s football has not left Iceland untouched, with 7.375 registered female players in June 2017, an increase of 21% since 2013. Of those 7.375 players, there are 30 professional players and 173 semi-professional players registered in teams within the Icelandic football association (UEFA, 2016). It could be argued that women’s football in Iceland has developed fast since the first organized match was played in 1970. (Víðir Sigurðsson, 1997). For the past decade, Iceland has been successful in European football, with the women’s national team qualifying for the last three UEFA Euro Cups (Sigurðsson, 2009; Sigurðsson, 2013; UEFA, 2016) The current aims of the Icelandic Football Association (Knattspyrnusamband Íslands, KSÍ) are to improve the level of coaching further, and increase the support and professionalism around the women’s national teams, to enhance the development of future national team players, as well as helping the senior national team to qualify for the FIFA women’s World Cup in France 2019 (KSÍ, 2018).

With the current aims and ambition of the Icelandic FA for women’s football, inevitably one wonders what defines an elite female football player at international competitive standards, and if there is an optimal progression across various ages.
1. Theoretical background

1.1 Physical demands of match play in female elite football

Studies conducted with time-motion analysis from female football report that players cover a total distance of approximately 10 km, where low-speed activity such as walking and jogging accounts for 80 – 90% of the distance. The rest is categorized as a high-speed activity, such as high intensity running and sprinting (Datson, et al., 2017). During a match, players are reported to change activity every 4 seconds and perform repeated high-intensity activities, such as jumping, kicking, tackling and heading the ball (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005).

It is well documented that demands of match-play vary significantly between levels of competition and playing-position. This is evident in the technical report of the FIFA World Cup 2015, where outfield players, that is all players excepts goalkeepers, were reported to cover on average total distance of 10.7 km per match, with central defenders (CD) covering the shortest distance 10.0 km and central midfielders (CM) covering the longest distance 11.2 km. The average distribution in speed zones for outfield players was 70% at 0-12 km/h, 18% at 12-16 km/h, 8% at 16-20 km/h and 4% at >20 km/h. A significant difference was found between playing-positions regarding distance covered in speed zones and number of performed sprints, whereas the CM covered longer distance significantly at 16-18 km/h compared to other playing positions. The wide midfielders (WM) had the largest distance covered at 18-20 km/h, and the WM and the forwards (F) had the highest distance covered at 20-23 km/h. Fullbacks (FB), WM and F, had the highest number and sprints >23 km/h per match; 24-25 with the average distance of 14 m, whereas CD performed on average 15 and CM 18 with an average distance of
13 m. Goalkeepers (GK) were reported to cover on average 5.5 km per match, whereas 68% was walking (0-6 km/h) and 1.6% high intensity running (>16 km/h). The largest number of sprints performed by goalkeepers was between 0-5 m (FIFA, 2016).

1.2 Physical fitness of female elite football players

At an elite level, physical fitness is highly important to meet the physical demands of the game and maintain your technical abilities throughout the match (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005). An assessment of anthropometry and the physical capacities of players can provide useful information for coaches and players to adapt to the demands of the match-play to be successful at all levels of competition (Martinez-Lagunas, Niessen, & Hartmann, 2014). Therefore, the objectives of this theoretical background are to review the available literature in female football assessing the basic anthropometry and physical characteristics of elite players, with special attention to playing-positions and age.

1.2.1 Basic anthropometry in female football

Basic anthropometry of female football players is reported after all major FIFA tournaments in technical reports. An analysis from the most recent FIFA Women’s World Cup in 2015 reported the average height, 167±6.7cm, (range 140-187cm), and average weight, 60.3±6.3kg (45-82kg), for all players at the tournament. However, BMI was not reported (FIFA, 2016). Unfortunately, this is often the case as most research in female football does not report BMI values, making it difficult to collect data on the matter.
In a review of the literature from 2014, Nikolaidis found 27 studies in female football that reported BMI or provided sufficient information to calculate participants BMI. In these studies, average BMI ranges from 21.0 to 24.2 kg/m². His findings indicate that as the level of competition lowers the BMI values increase and concludes that BMI values around 22 kg/m² are optimal for the elite level (Nikolaidis, 2014). More recent studies conducted on elite female football players support these statements, as Mala et al. (2015) reported the mean BMI values of the Czech women’s national team as 21.9 ± 1.6 (Mala, et al., 2015).

1.2.1.1 Basic anthropometry and playing positions

Even though it appears that there is a consensus of the optimal BMI for elite female football player’s, values for height and weight vary as football teams tend to be characterized by a heterogeneous composition of body sizes (Reilley, Bagsbo, & Franks, 2000). Knowledge about differences in anthropometry by playing-position in elite female football is limited, but research suggests that similar to men’s football, female goalkeepers, and defenders tend to be taller and heavier compared to other playing positions (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005; Martinez-Lagunas, Niessen, & Hartmann, 2014). These statements are supported by Ingebrigtsen et al. that investigated a group of elite female football players and found that defenders were on average five cm taller and had higher body mass than other playing-positions; however these differences were not significant (Ingebrigtsen, Dillern, & Shalafawi, 2011). Similar results have been reported from the Serbian A-national team in 2012, whereas goalkeepers were on average 5 cm taller than midfielders and 8 cm taller than forwards (Milanovic, Sporis, & Trajkovic, 2012).
The reasons for these differences are believed to be due to tactical purposes of the game, where tall goalkeepers and defenders have a certain competitive advantage while dealing with long and high passes (Reilley, Bagsbo, & Franks, 2000).

1.2.1.2 Development of anthropometry in female adolescent players

The onset of peak height velocity for girls is reported to be from the age of 11 to 16.5 (Ford, et al., 2011). In the first cross-sectional study (Emmonds et al., 2018) presenting anthropometric and performance characteristics of high-level youth female football players in England, aged 10-16, it was reported that anthropometric measures were greater in older players, and that would most likely or very likely increase their body mass and height annually during that period. These differences in height and body mass are attributed to increased maturity and biological, hormonal and neurological changes (Emmonds, et al., 2018). These results are in accordance with Portuguese female football players aged 9-16 years (Póvoas, et al., 2016).

1.3 Power in female football

The energy used during a football match is predominantly provided by the aerobic system or up to 90% (Hoff, Wislöff, Engen, Kemi, & Helgerud, 2002). Despite this dominance, the most decisive actions of each game are covered by the anaerobic metabolism. Thus, it has been reported that short, intense sprints are the most effective part of football team’s offensive play at an elite level, whereas most goals are scored after powerful actions, such as a linear sprint or a jump (Faude, Koch, & Meyer, 2012). These activities depend upon anaerobic energy release and are considered both dependent on playing-position and competition level (Stölen,
Chamari, Castagna, & Wislöff, 2005). Results from multiple tests can be found in the literature, reporting anaerobic power within female football players. The methods most commonly used to evaluate lower body power in football are jumps, sprints and agility tests (Mujika, Santisteban, Impellizzeri, & Castagna, 2009; Martinez-Lagunas, Niessen, & Hartmann, 2014).

1.3.1 Extension leg power

The countermovement jump (CMJ) is a commonly used method to evaluate jump height within football players (Bosco, Luhtanen, & Komi, 1983). It has been reported as both valid and reliable to measure lower body power for athletes (Rosell, Custodio, Franco-Márquez, & Badillo, 2016). In female competitive football, reported values for CMJ and vertical jump range from 28 to 50 cm, depending upon the competitive level (Martinez-Lagunas, Niessen, & Hartmann, 2014). Acceleration, speed and power of youth players are dependent upon the maturational status of players, as well as muscle mass. Thus, increases in muscle mass and motor unit activation are strongly linked to muscular power (Ford, et al., 2011).

Several studies have reported data from elite female football players. Krstrup et al. (2010) reported in their study of 23 elite Danish football players, that the average height of CMJ measured with a force plate was 30 ± 1 (range 30 to 45 cm) (Krstrup, Zebis, Jensen, & Mohr, 2010). Based on an analysis of the Italian senior, U17 and 19 national teams using Bosco’s CMJ protocol, Castagna and Castellini (2013) reported that for female elite football players aged 17 and older, CMJ above 34.4 cm should be regarded as a sign of superior vertical jump abilities and that a CMJ of 29.8 cm should be considered as a threshold for discriminating between competitive levels in elite standard football players (Castagna & Castellini, 2013).
1.3.1.1 CMJ and playing position

Various articles have been published investigating differences in assessed CMJ performance and playing position. A Norwegian study, examining the speed and countermovement jump characteristics amongst female competitive football players in various competitive levels from 1995 to 2010 found no significant difference between playing-positions or across age groups in countermovement jump measured with a force platform (Haugen, Seiler, & Tönnessen, 2012). In College division I female football, both Lockie et al. (2018) and Vescovi et al. (2006) have investigated CMJ performance between goalkeepers, defenders, midfielders and forwards. Both studies reported similar performance within playing-positions, with Vescovi et al. reporting an average of 2 cm higher jumps by forwards and midfielders. However, this difference was not significant (Vescovi, Brown, & Murray, 2006; Lockie, et al., 2018).

1.3.1.2 CMJ and age

Several articles have been published reporting CMJ performance across age groups. In an analysis of 414 high-level female soccer players, aged 12 to 21 years, Vescovi et al. (2011) reported that CMJ performance increased to the age of 15-16 years before stabilizing until the age of 21. These results are similar to research conducted in other sports within adolescent female athletes that show improvement in CMJ until 15 years of age (Vescovi, Rupf, Brown, & Marques, 2011). In another study by Vescovi et al. (2007), they reported no difference in CMJ performance between female high school soccer players and female college soccer players (Vescovi & McGuigan, Relationship between sprinting, agility and jump ability in female athletes, 2007). Mujika et al. (2009) reported a significant difference in CMJ performance and
active CMJ (with arms wing) between senior females (age; 23.1 ± 2.9 years) and junior females (age; 17.3 ± 1.6 years) in Spanish football (Mujika, Santisteban, Impellizzeri, & Castagna, 2009).

In the Norwegian analysis, Haugen et al. (2012) found no age-related differences in sprint or CMJ performance amongst their participants (Haugen, Seiler, & Tönnessen, 2012). A cross-sectional analysis Emmonds et al., (2018) reported that players would very likely improve their CMJ height annually from 14 to 16 years old (Emmonds, et al., 2018).

1.3.2 Agility

In football, intense agility actions can distinguish between a win and a loss (Little & Williams, 2005). According to Sheppard and Young (2006), agility is influenced by explosive strength, coordination, balance, and flexibility and can be defined as the ability to change directions rapidly (Sheppard & Young, 2006). As most match analysis report only distance covered, the number of performed headers, tackles, and jumps, limited evidence exist on the match play agility demands in female elite football, such as the number of completed accelerations, decelerations and change of direction (Haugen, Seiler, & Tönnessen, 2012). However, these data are well documented within men’s football and provide an idea of the agility demands of women’s football. An analysis from the Premier League showed that 40.4% of decelerating post sprinting was followed by a shuffling movement and other 12.6% by immediately sprinting (Bloomfield, Polman, & O’Donoghue, 2006). Another study (Sporis et al., 2010) reported that during every match, players change direction on average every 2 to 4 seconds, a total of 1200-1400 in a game, of which 220 are performed with high intensity (Sporis, Jukic, Milanovic, & Vucetic, 2010).
Result from various agility tests within female football is reported in the literature, such as; 15 m slalom test (Mujika, Santisteban, Impellizzeri, & Castagna, 2009), The Step 50 test, (Hasegawa & Kuzuhara, 2015), the Arrowhead COD speed test (Lockie, et al., 2018), the Pro Agility test (Polman, Walsh, Bloomfield, & Nesti, 2004) the 505 COD test (Emmonds, et al., 2018) and the Illinois Agility test (Vescovi, Rupf, Brown, & Marques, 2011).

1.3.2.1 Agility and playing positions

Within female football, limited research exists investigating performance in agility tests by playing-position. Three studies can be found comparing GK, D, M, F in Division I College Soccer. In a study from 2018, Lockie et al. found no significant difference between playing positions in either the Pro-agility test or the Arrowhead test in Division I female college players (Lockie, et al., 2018). A Japanese study from 2015 showed no significant differences between playing-positions in the Step 50 test (Hasegawa & Kuzuhara, 2015). Vescovi et al. (2006) reported that M and F performed better in the Illinois Agility Test compared to GK and D, however, these differences were not statistically significant (Vescovi, Brown, & Murray, 2006).

1.3.2.2 Agility and age

In their study investigating the development of high-level female football players from the age of 12 to 21 years old, Vescovi et al. (2011) reported that most improvements were seen in the modified Illinois Agility test between the players at the age of 12-13 years, followed by a modest improvement until 16 years old. After the age of 16, a platue occurred. A tendency was noticed for younger athletes (aged 13-15 years) to have slower times on both the modified Illinois test
and the Pro Agility test compared to older athletes (aged 17-20 years) (Vescovi, Rupf, Brown, & Marques, 2011). In their analysis, Emmonds et al. (2018) reported an improvement in 505 COD test for both dominant and non-dominant foot with 14-16 year old players (Emmonds, et al., 2018). Mujika et al. (2009) found a significant difference between performance in 15 m - Agility test between senior female players (age; 23.1 ± 2.9 years) and junior females (age; 17.3 ± 1.6 years), whereas junior players were significantly faster than the seniors (Mujika, Santisteban, Impellizzeri, & Castagna, 2009).

1.3.3 Sprinting

In women’s football, players perform high intensity running (HIR) 120 to 150 times during each match. These high-intensity runs are on average 2 to 3 seconds and represent 8 to 12% of total running distance covered in each match (Haugen, Seiler, & Tönnessen, 2012). A large variability has been established in the distance covered at high intensity and sprinting between competition levels, whereas total distance covered remains almost the same independent of competition, while HIR and sprinting is increased (Martinez-Lagunas, Niessen, & Hartmann, 2014).

1.3.3.1 Sprinting and playing position

In the Norwegian study, Haugen et al. (2012) reported a large velocity difference across competition levels and playing positions. In that study, F were reported 3-4% faster than M and GK and D 2% faster than M, over 0-20 m (Haugen, Seiler, & Tönnessen, 2012). Vescovi et al. (2006) reported a different trend indicating D to be slightly slower compared to M and F in
18.28 m sprint and 36.58 m sprint (Vescovi, Brown, & Murray, 2006). Lockie et al. (2018) reported that in a 30 m sprint, midfielders were significantly faster over 0-5 m than defenders and goalkeepers, however, no significant difference was found over 0-10 m and 0-30 m interval (Lockie, et al., 2018). Hasegawa & Kuzuhara found no significant difference between playing-positions in 20 m sprint (Hasegawa & Kuzuhara, 2015).

1.3.3.1 Sprinting and age

As previously stated are accelerations, speed and power of youth players dependent upon the maturational status of players, as well as muscle mass (Ford, et al., 2011). Studies reporting sprinting performance across various age groups support these statements, whereas Vescovi et al. (2011) report an improvement in 36.6-meter sprint within high-level female football players from the age of 12 until 17 years old, with an average improvement at the last 9.1 m of 4.8% (Vescovi, Rupf, Brown, & Marques, 2011). The article by Haugen et al. (2012) reported a significant difference between junior elite players and the national team players, whereas junior elite players ran on average on 4.44 second and national team players ran the distance in an average time of 4.35 seconds (Haugen, Seiler, & Tönnessen, 2012). Mujika et al. (2009) found no significant difference between junior and senior females in a 15 m sprint (Mujika, Santisteban, Impellizzeri, & Castagna, 2009). In their analysis of English youth players, Emmonds et al. (2018) reported that older players were quicker in both 10 m and 30 m sprint, whereas the greatest changes were observed between the ages of 10 and 12 years old, with an improvement reported at all ages (10-16) (Emmonds, et al., 2018).
1.4 Endurance

1.4.1 Aerobic endurance

Due to the length of football matches, 90% of the energy used by players is provided with aerobic energy systems (Hoff, Wislöff, Engen, Kemi, & Helgerud, 2002). Therefore, high-level aerobic endurance helps players to maintain a high intensity and resist fatigue during the game, providing a competitive advantage (Martínez-Lagunas, Niessen, & Hartmann, 2014). To evaluate the physiological strain on the aerobic system during a football match studies have investigated both heart rate and oxygen uptake. Currently, the most accurate method to evaluate aerobic endurance is by measuring maximum oxygen uptake, VO$_2$Max, which represents the body’s ability to utilize oxygen (Wilmore, Costill, & Kenney, 2012).

Two studies have reported peak and average oxygen uptake during a female football match. In an analysis conducted by Krstrup et al. (2005) on 14 elite Danish female football players, it was reported that average VO$_2$ uptake was 37.6 ml/kg/min during the match or 77% of VO$_2$Max, and peak VO$_2$ uptake was 47.4 ml/kg/min or 96% of VO$_2$Max. These reported values are based on an indirect estimation via HR-VO$_2$ relationship (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005). In the only study conducted with a portable spirometry, Martínez-Lagunas et al. (2014) reported average and peak VO$_2$ values from 2. and 4. division players in Germany. Their results reported an average value of 28.3± 4 ml/kg/min or 52% of VO$_2$Max and peak values of 53± 3.8 ml/kg/min or 98% of VO$_2$Max (Martínez-Lagunas, Niessen, & Hartmann, 2014).

The physiological load during a football match measured as the percentage of maximal heart rate (HR$_{max}$) is close to the anaerobic threshold between 80 and 90%, indicating that the
aerobic energy system is highly taxed during match play (Stölen, Chamari, Castagna, & Wislöff, 2005). In their match analysis report, Krustrup et al. (2010) reported an average heart rate (HR_{avg}) during the match at 168 ± 1, and peak heart rate (HR_{peak}) 194 ± 2. These numbers are correspondent to HR_{avg} of 86% and HR_{peak} of 98% (Krustrup, Zebis, Jensen, & Mohr, 2010).

To date, the most common method to assess the aerobic endurance of football players is by using field tests. In football, the Yo-Yo tests have been established as a good test to evaluate aerobic endurance. The reliability and validity of the Yo-Yo Intermittent Recovery (YoYo IR) tests are well documented within the football society (Bangsbo J., Mohr, Poulsen, Perez-Gomes, & Krustrup, 2006). Recently large correlation has been established between Yo-Yo Intermittent Endurance test level 2 (YoYo IE2) performance and total distance covered and high intensity running (> 15km/h) for elite senior players during a competitive match (r = 0.7). The test has also been validated as a sensitive and reproducible tool, providing results related to running performance during competitive matches (Bradley, et al., 2014). As such, the Yo-Yo IE2 test mainly taxes the aerobic energy system, but towards the end of the test a large contribution is observed from the anaerobic system (Bangsbo & Mohr, 2012).

### 1.4.1.1 Aerobic endurance and playing positions

Although performance in the YoYo tests is not as widely established in the female literature as the males, two studies have been published in elite female football. Krustrup et al. (2010) reported that 23 female Danish outfield football players playing at elite level in the Danish league performed 1.213 ± 90 m in the YoYo IE2 test (Krustrup, Zebis, Jensen, & Mohr, 2010). More recently, Bradley et al. (2014) conducted a study to evaluate the application of the YoYo
IE2 test to elite female populations. A total of 199 female soccer players took part, and were categorized based on their competition level and age to; elite senior, elite youth, domestic and sub-elite. Significant differences were observed between playing-positions for both elite senior and elite youth players. For elite senior players, \((n = 92; \text{age } 23 \pm 2)\) wide midfields (WM) had higher YoYo IE2 performances, \((2057 \pm 550 \text{ m}, p < 0.05, n = 19)\) than central defenders (CD) \((1588 \pm 534 \text{ m}; n = 21)\) and forwards (FW) \((1516 \pm 401 \text{ m}, n = 16)\) but not central midfields (CM) \((1764 \pm 473 \text{ m}, n = 21)\) or (WD) \((1964 \pm 522 \text{ m}, n = 15)\). For elite youth players \((n = 42; \text{age } 19 \pm 1)\) differences \((p < 0.05)\) were observed between WM \((n = 6)\) and CM \((n = 12)\) \((1760 \pm 395 \text{ m}; 1727 \pm 349)\) compared to CD \((1151 \pm 261 \text{ m}; n = 9)\) but not FW \((1273 \pm 161 \text{ m}; n = 6)\) or WM \((1480 \pm 610 \text{ m}; n = 9)\) (Bradley, et al., 2014).

1.4.1.2 Aerobic endurance and age

A review article by Harrison et al. (2015), investigating the development of aerobic fitness in young team sport athletes reported that absolute VO\(_2\) MAX increases approximately 200 ml/min each year prior to puberty, and continues to increase until approximately 13 years of age in females. VO\(_2\) MAX continues to increase at all ages after girls reach their peak height, but the increase is predominantly attributed to changes in central mechanisms such as heart, lungs, muscles and blood volume (Harrison, Gill, Kinugasa, & Kilding, 2015).

It has been reported that older players achieve greater distances in Yo-Yo test performances. This is likely due to increased training and match exposure, as well as increase in match intensity with older age (Emmonds, et al., 2018). This is in an agreement with Bradley’s et al (2014) results, reporting a significant difference between senior elite (age 23 ± 2) and youth
elite (age 19 ± 1) in YoYo IE2 performance, (1774 ± 532m vs. 1490 ± 447m) (Bradley, et al., 2014) and Mujika´s et al. (2009) results reporting significant differences in the YoYo IR 1 test between junior (age; 17.3 ± 1.6) and senior (age; 23.1 ± 2.9) females in Spanish elite football (Mujika, Santisteban, Impellizzeri, & Castagna, 2009).

1.4.2 Anaerobic endurance

As previously described the average work intensity in a football match is close to the anaerobic threshold, whereas the production and removal of lactate is equal. However, during each football match there are periods of repeated high intensity activities, such as repeated sprint bouts (RSB), where the accumulation of lactate takes place (Stölen, Chamari, Castagna, & Wislöff, 2005). A weak, but significant ($r = .41$), correlation has been established between muscle lactate and decreased sprinting performance after intense periods of match-play (Mohr, Krustrup, & Bangsbo, 2005). Due to difficulties in procedures and high costs, studies reporting blood lactate during a football match within the female population are limited. In a review article by Martinez-Lagunas et al. they reported that within female football, seven studies had provided blood lactate levels (mmol/L) at various stages of match play, ranging from 2.2 to 7.3 mmol/L (Martinez-Lagunas, Niessen, & Hartmann, 2014).

The ability to perform repeated sprints during a football match is well established, whereas RSB are reported to occur immediately before a goal is scored, suggesting that they might be critical to match outcome (Gabbett T., 2010). In a match analysis of thirteen elite female football players during 15 matches, Gabbett et al. (2013) reported that players perform
Various protocols have been developed in an effort to assess the repeated sprint ability in football players (Datson, et al., 2014). Based on the match-play demands of international female elite football, Gabbett et al. (2010) developed the 6 x 20 m sprint test, with a 15 second recovery interval between sprints (Gabbett T. , 2010). Another method to assess the repeated sprinting ability of football players is the Linear sprint test, developed by Bangsbo et al. (2012), where players perform repeated bouts of linear 30 m sprints with 25 second interval. The aim of the test is to assess ATP and CP system, glycolysis and the aerobic system of players. The aerobic system is especially stressed during the recovery intervals where rebuilding of CP is highly dependent of the oxygen delivery and utilization in the muscle (Bangsbo & Mohr, 2012). Krustrup et al. (2005) assessed the repeated sprint ability within Danish elite female football players aged 18-29 years old, using the Linear sprint test. They reported an average reduction of 4% in 3 x 30 m sprinting time (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005).

1.4.2.1 Anaerobic endurance and playing position

To the author’s knowledge, limited information is available about the differences in physical tests that assess the anaerobic endurance between playing-positions in female football. However, large variety has been established in performed RSB in elite competitive level between playing-positions during match-play. Gabbett et al. (2013) reported in their analysis that RSB varied from 0-23 performed RSB by players, where the number of RSB was generally higher for CM than WM, FW and CD (Gabbett, Wiig, & Spencer, 2013). In another analysis of
RSB, CD performed significantly lower number of RSB than fullbacks, CM and FW (Nakamura, et al., 2016).

Within men’s football, Kaplan examined the repeated sprinting ability of 85 amateur football players by their playing-positions; GK, D, M, F, using a 7 x 34.2 m protocol developed by Bangsbo. Their results showed no significant difference between positions in best time, average time and fatigue index (Kaplan, 2010).

1.4.2.2 Anaerobic endurance and age

To date, little information exists about the development of repeated sprinting ability within highly trained adolescence. The first study assessing repeated sprint ability across age groups was conducted on male Spanish elite football players aged 11-18. There, the players performed 6 x 30 m linear sprint test. A significant improvement was reported between all age groups from U-11 to U-15 for both peak and mean sprinting. A small but non-significant improvement was reported between age groups U-15 to U-18 for both peak and mean sprint time. However, no significant differences were found between age groups for Fatigue index, the percentile sprint decrement, varying from 4.0 to 5.5% (Mujika, Spencer, Santisteban, Goiriena, & Bishop, 2009).
1.5 Specific skill

1.5.1 Kicking

Kicking is one of the most important skills in football, defining the sport as it the most used and most determinant skill during competition (Lees, Asai, Andersen, Nunome, & Sterzing, 2010). It has been reported in female youth football that teams perform on average 94 ± 7 long passes, 144 ± 19 short passes, 9 ± 2 crosses, 6 ± 1 free kicks, 6 ± 1 corners and 16 ± 4 shots on goal (Andersen, et al., 2012). Thus, highlighting the importance of kicking abilities.

Kicking performance is most commonly evaluated by maximum ball velocity and accuracy, (Rodriguez-Lorenzo, Martin-Acero, Fernandez-del-Olmo, & Sanchez-Molina, 2016) whereas ball velocity is a result of various factors such as approach and angle, technique, type of kick, dominant foot, skill level, gender, age, maturity, muscle strength, and power (Kellis & Katis, 2007). Research report average values for ball velocity within female football players up to 22 m/second (Kellis & Katis, 2007). In an analysis of Danish female football players aged 15-18 years old, Andersen et al. reported average ball velocity 80 km/h (Andersen, et al., 2012). Barfield et al. (2002) reported that average ball velocity for six elite female football players while kicking with the dominant foot was 72 km/h and 65 km/h with the non-dominant foot (Barfield, Kirkendall, & Yu, 2002).

1.5.1.1 Kicking velocity and playing position

To the author’s knowledge, no research has been published assessing kicking velocity between playing positions.
1.5.1.2 Kicking velocity and age

Research of kicking velocity across age groups is limited within female football. However, Vieira et al. reported in a study investigating the kicking performance in 9 to 20 year old Brazilian male football players that ball velocity increase by 103% from the U-11 group to the U-20 group, whereas a significant difference was found between all age groups; U-20, U-17, U-15, U-13, U-11 and U-9. The authors conclude that these results can be attributed to increase in strength capacity, increased practice time and thereby improved technique. (Vieira, et al., 2018).

1.6 Summary

It is evident that information about the physical characteristics and body composition of youth elite female football players is lacking across age groups and playing positions. Tables 1 and 2 summaries the articles previously reviewed reporting basic anthropometry, physical fitness and technical abilities by playing-position and age.
Table 1. - Basic anthropometry, physical fitness and specific skill within female football players by playing-position

<table>
<thead>
<tr>
<th>Study</th>
<th>Level</th>
<th>Country</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI kg/m²</th>
<th>Height (cm)</th>
<th>Time (sec)</th>
<th>Time (sec)</th>
<th>YoYo IE2 (m)</th>
<th>RSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martinez-Lagunas et al. 2014</td>
<td>Elite</td>
<td>Multiple</td>
<td>G,D &gt; M,F*</td>
<td></td>
<td></td>
<td>G,D &gt; M,F*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milanovic et al. 2012</td>
<td>Elite</td>
<td>Serbia</td>
<td>G &gt; M, F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haugen et al. 2012</td>
<td>Elite</td>
<td>Norway</td>
<td>G &gt; M, D</td>
<td></td>
<td>*</td>
<td>F &lt; M, G; D &lt; M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vescovi et al. 2006</td>
<td>College div. I</td>
<td>USA</td>
<td>↑ until 15</td>
<td></td>
<td>↓ until 16</td>
<td>↓ until 17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lockie et al. 2018</td>
<td>College div. I</td>
<td>USA</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hasegawa &amp; Kuzuhara., 2015</td>
<td>College div. I</td>
<td>Japan</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bradley et al. 2014</td>
<td>Senior elite</td>
<td>Denmark</td>
<td>WM &gt; CD, F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Kg = kilograms, Cm = Centimeters, BMI = Body mass index, CMJ = countermovement jump, Sec = seconds, YoYo IE2 = Yo-Yo Intermittent endurance test level 2, M = meters, RSA = Repeated sprint ability, G = Goalkeeper, D = Defender, M = Midfielder, F = Forward, * = not statistically significant difference, WM = Wide midfielder, CD = Central defender, CM = Central midfielder, div = division

Table 2. - Basic anthropometry, physical fitness and specific skill within female football players by age

<table>
<thead>
<tr>
<th>Study</th>
<th>Age group (years)</th>
<th>Country</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI kg/m²</th>
<th>Height (cm)</th>
<th>Time (sec)</th>
<th>Time (sec)</th>
<th>YoYo IE2(m)</th>
<th>RSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vescovi et al., 2011</td>
<td>(12-21)</td>
<td>USA</td>
<td>↑ until 15</td>
<td></td>
<td>↓ until 16</td>
<td>↓ until 17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vescovi &amp; McGuigan, 2007</td>
<td>High School vs. College</td>
<td>USA</td>
<td>No diff.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mujika et al. 2009</td>
<td>Senior (23.1)</td>
<td>Spain</td>
<td>Senior &gt; Junior</td>
<td>Junior &gt; Senior</td>
<td>No diff.</td>
<td>Senior &gt; Junior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haugen et al. 2012</td>
<td>Senior (23.5)</td>
<td>Norway</td>
<td>18-19 &gt; u18</td>
<td>No diff.</td>
<td>.</td>
<td>Senior &lt; Junior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bradley et al. 2014</td>
<td>Senior (23)</td>
<td>Denmark</td>
<td>Senior &gt; Junior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emmonds et al. 2018</td>
<td>(10-16)</td>
<td>England</td>
<td>Most likely</td>
<td>Very likely</td>
<td>Very likely</td>
<td>Very likely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Kg = kilograms, Cm = Centimeters, BMI = Body mass index, CMJ = countermovement jump, Sec = seconds, YoYo IE2 = Yo-Yo Intermittent endurance test level 2, M = meters, RSA = Repeated sprint ability, No diff. = No difference between age groups, ↑ = increase, ↓ = decrease
Due to insufficient sample size, most previous studies investigating differences in physical characteristics between playing-position in female football have used a general categorization of playing positions, goalkeepers, defenders, midfielders and forwards (Bradley, Dellal, Mohr, Castellano, & Wilkie, 2014). As concluded by Martinez-Lagunas et al. (2014), this generalization could be misleading, whereas the physical demands placed in the external and central positions during match play are significantly different. Thus, suggesting that a more detailed classification is needed including at least six categories; goalkeepers, central defenders, external defenders, central midfielders, external midfielders and forwards (Martinez-Lagunas, Niessen, & Hartmann, 2014). However, in a recent analysis of the physical demands of competitive international female match-play Datson et al. (2017) reported that the physical performance by external players, wide defenders and wide midfielders, was generally similar as no differences were observed in total distance covered, HSR or sprinting distance (Datson, et al., 2017). Based on this information, the objective of this descriptive analysis was to:

- Evaluate and identify the basic anthropometry, physical fitness and kicking velocity of the female Icelandic youth national teams in function by playing positions and age.
2. Methods

2.1 Study design

This is a descriptive cross-sectional analysis done in collaboration with the Icelandic FA, Knattspyrnusamband Íslands. It covers the basic anthropometry, physical fitness, and specific skill characteristics within Icelandic female youth national team players over a three month period, from 10.11.2017 to 11.2.2018.

2.1.1 Testing variables

The dependent variables in this descriptive cross-sectional analysis were two, age and playing position. The age was calculated with one decimal, using the player’s date of birth and the date of the test session. For players with multiple test sessions results, the date of the session with the highest number of best performances was used.

The national team coaches categorized all players into five different playing-positions; goalkeeper, central defender, wingback, central midfielder and forward. This was decided based on an analysis of match-play demands recently described by Datson et al. (2017) (Datson, et al., Match Physical Performance of Elite Female Soccer Players During International Competition, 2017).

Results from each test were used as independent variables for the analysis. The independent variables, as well as their measurement units, are presented in table 3.
Table 3. Variables and their units.

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Independent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (xx.y)</td>
<td>Height, weight and BMI (cm, kg, kg/m²)</td>
</tr>
<tr>
<td>Playing position (goalkeeper, central defender, wingback, central midfielder, forward)</td>
<td>Countermovement jump (cm)</td>
</tr>
<tr>
<td></td>
<td>Modified Abalakov Jump test (cm)</td>
</tr>
<tr>
<td></td>
<td>Illinois Agility Test (seconds)</td>
</tr>
<tr>
<td></td>
<td>5 x 30 m RSA (fastest sprint-s, fatigue index-%)</td>
</tr>
<tr>
<td></td>
<td>Yo-Yo IE2 (meters)</td>
</tr>
<tr>
<td></td>
<td>Kicking velocity (km/h)</td>
</tr>
</tbody>
</table>

xx.y = age in years with one decimal, cm = centimeters, kg = kilograms, BMI = Body mass index, RSA = Repeated sprinting ability, km/h = kilometers an hour

2.2 Participants

A total of 85 female football players representing the Icelandic national teams were included in this study. The participants involved represented the under 16 years (U-16), under 17 years (U-17) and under 19 years (U-19) national teams. The total number of players tested and birth year for each team is described in table 4.

Table 4. Number of participants included and their birth year

<table>
<thead>
<tr>
<th>Team</th>
<th>Total number of players</th>
<th>Year of birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-16</td>
<td>33</td>
<td>2002-2003</td>
</tr>
<tr>
<td>U-17</td>
<td>27</td>
<td>2001</td>
</tr>
</tbody>
</table>

U-16 = under 16 years old, U-17 = under 17 years old, U-19 = under 19 years old

The National Team coaches chose the players two weeks before each training camp. For this reason, several changes were between participants in each national team group between test sessions. Detailed participation is explained in table 5.

Players were excluded from the testing if they experienced pain or severe muscle stiffness, or if the national team physiotherapist concluded that it was not safe for the player to participate due to injuries or sickness.
Table 5. Detailed participation in testing sessions by national teams

<table>
<thead>
<tr>
<th>Participation</th>
<th>1. session (n)</th>
<th>2. session (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U – 16 participation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First invitation</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>- <em>Of which absence due to sickness/injuries</em></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Invited due to sickness/injuries of absence players</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Showed (N of clubs represented)</td>
<td>23 (16)</td>
<td>26 (16)</td>
</tr>
<tr>
<td>Participated in the session (N participated in the first session)</td>
<td>23</td>
<td>26 (17)</td>
</tr>
<tr>
<td>Participated in a match the day before, minimum 45 min</td>
<td></td>
<td>5 (Yo-Yo IE2), 1</td>
</tr>
</tbody>
</table>

Skipped a test (N, test name) | (5x30 RSA) |

Tested with another national team age group due to absence (N, team, date) | 1, U-19 |

| **U – 17 participation** |               |               |
| First invitation | 25            | 18            |
| - *Of which absence due to sickness/injuries* | 2             | 4             |
| Invited due to sickness/injuries of absence players | 2             |               |
| Showed (N of clubs represented) | 23 (13)       | 16 (11)       |
| Participated in the session (N participated in the first session) | 23            | 16 (13)       |
| Involved in a match the day before, minimum 45 min | 5             |               |
| Skipped a test (N, test name) | 2, U-19, 4, Yo-Yo IE2 |
| Tested with another national team age group due to absence (N, team, date) | 24.11.2017 |

| **U – 19 participation** |               |               |
| First invitation | 16            | 22            |
| - *Of which absence due to sickness/injuries* | 1             | 4             |
| Invited due to sickness/injuries of absence players | 1             |               |
| Showed (N of clubs represented) | 15 (12)       | 19 (12)       |
| Participated in the session (N participated in the first session) | 15            | 19 (17)       |
| Involved in a match the day before, minimum 45 min | 5             |               |
| Skipped a test (N, test name) | 6, U-23, 1, Yo-Yo IE2 |
| Tested with another national team age group due to absence (N, team, date) | 24.11.2017 |

*U-16 = under 16 years old, U-17 = under 17 years old, U-19 = under 19 years old, N = number, Min = minutes, Yo-Yo IE2 = Yo-Yo intermittent endurance test level 2, 5x30 RSA = 5 x 30 m repeated sprinting ability*
2.3 Procedure and materials

2.3.1 Location and testing frequency

Each national team was measured two times during the preseason prior to the 2018 competitive season. Data was collected in the period from November 2017 to February 2018. During the time the players had between one and three trials to perform the tests, depending upon if they were chosen by the National Team coaches. Test session dates by each national team are listed in table 6.

<table>
<thead>
<tr>
<th>Team</th>
<th>Session 1 (date)</th>
<th>Session 2 (date)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-16</td>
<td>10/11/2017</td>
<td>11/2/2018</td>
</tr>
<tr>
<td>U-17</td>
<td>10/11/2017</td>
<td>25/1/2018</td>
</tr>
<tr>
<td>U-19</td>
<td>24/11/2017</td>
<td>25/1/2018</td>
</tr>
</tbody>
</table>

*U-16 = under 16 years old, U-17 = under 17 years old, U-19 = under 19 years old*

All test-sessions, except the last (11.2.2018), were a part of the first training to a weekend-long training camp. They took place on a Friday evening in Kórinn, an indoor arena with a full-size artificial turf football field. The last session took place on a Sunday morning in Egilshöll Arena, identical to Kórinn.

2.3.2 Inclusion criteria for data analysis

Data from all six test session were included in this analysis, two sessions for each national team age group. Data were collected from 85 players, of which 47 participated in two sessions, and three participated in three sessions. All players were included in the analysis. As the data collection period was considered as one session, the best results were collected independent of
which day the test was conducted. For players participating in more than one session, the date including the highest number of best performances was used for age calculation. This was decided as the average time between test sessions was 11 weeks (9-13), and during that time training load varied between the domestic clubs of players. Thus, it was assumed that the variability in age calculation would level out, and present the best physical characteristics of players.

2.3.3 Ethical considerations

As all participants were female, a decision was made that all activities requiring close contact with the participants would be performed by a female staff member, or at least with a female staff member included in the activity. These activities were for example; application of stickers and tape, and assessment of height and weight.

As these tests were conducted for the Icelandic FA, KSÍ, all clubs within the association were allowed to access results for their players, as well as average values and highest and lowest values for each test. The study was conducted according to the Declaration of Helsinki.
2.4 Test battery and testing procedure

The tests chosen for this study are outlined in table 7.

<table>
<thead>
<tr>
<th>Table 7. Test categories and specific tests used in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic anthropometry</td>
</tr>
<tr>
<td>a. Height</td>
</tr>
<tr>
<td>b. Weight</td>
</tr>
<tr>
<td>c. Body mass index</td>
</tr>
<tr>
<td>2. Physical fitness</td>
</tr>
<tr>
<td>a. Power</td>
</tr>
<tr>
<td>i. Countermovement jump (CMJ)</td>
</tr>
<tr>
<td>ii. Modified Abalakov jump (M. AJ)</td>
</tr>
<tr>
<td>b. Agility</td>
</tr>
<tr>
<td>i. Illinois Agility test</td>
</tr>
<tr>
<td>c. Anaerobic and aerobic (Capacity and Power)</td>
</tr>
<tr>
<td>i. 5 x 30 repeated sprinting ability (5x30 RSA)</td>
</tr>
<tr>
<td>ii. Yo-Yo Intermittent Endurance test level 2 (Yo-Yo IE2)</td>
</tr>
<tr>
<td>3. Technical abilities</td>
</tr>
<tr>
<td>a. Kicking velocity</td>
</tr>
</tbody>
</table>

2.4.1 Test-session set up

All players received a number at the beginning of each test-session, with the instruction to maintain their numerical order throughout the entire test course. Players were instructed to recover fully after each test before starting their next test. All players finished the first four tests before beginning the Yo-Yo IE2 test in two groups. The order of the tests, testing course, and field set up is explained in figure 1.
Before each testing-session, the players completed a 15-minute traditional warm-up instructed by the national team coaching staff. The coaching staff was asked to prescribe the same, or very similar, warm-up at each time. After the testing session started, players were asked to stay active and warm to get the best results possible and avoid injuries, the time available for each session was 75 minutes. The detailed setup and procedure of the test sessions and each test is described in this following section.
2.5 Basic anthropometry

2.5.1 Height, weight and body mass index (BMI)

- Reference: Keys and Brozek (1952)
- Objective: To evaluate the height, weight and body mass index of all participants.
- Testing procedure: Height and weight were measured for all players using height and weight scale. Players were required to remove their shoes but were allowed to wear their training outfit, socks, shorts, and a t-shirt. Body Mass Index was calculated for each player based on the formula presented by Keys et al. (Keys & Brozek, 1953)

\[ BMI = \frac{\text{weight in kilograms (kg)}}{\text{height in meters}^2 (m^2)} \]

- Equipment: Seca 220, height and weight scale
- Score: Height (centimeters), weight, (kilograms), BMI (kg/m\(^2\))

2.6 Physical fitness

2.6.1 Power

2.6.1.1 Countermovement jump

- Objective: To evaluate the lower body power of each player, the Countermovement Jump by Bosco was chosen (Bosco, Luhtanen, & Komi, 1983), as it is a valid and reliable method to
evaluate lower body power and the vertical jumping ability for football players. (Rosell, Custodio, Franco-Márquez, & Badillo, 2016)

- **Testing procedure:** The players were instructed to stand on the market “X” with hands on both hips and with feet hips width apart. See figure 2. When ready, the player was instructed to jump as high as possible in a single movement by flexing at hips, knees, and ankles to a comfortable depth and immediately extending at all three joints with as much force as possible, maintaining hands on hips throughout the entire movement. See figure 2. Each player got two attempts; the better one was included in the analysis. Before jumping, the players were marked with a strip of white tape on the caput fibulae of their right leg. The players were instructed to stand on the marked “X” and turn towards the camera to show their testing number. Then, the players turned, with their right leg towards the camera, showing their mark on caput fibulae. The mark was used to create a fixed point for the video analysis in Kinovea. During the video analysis, a grid was placed directly above the mark, see figure 2. As the players reached their maximum jumping height, the video was stopped and the distance from the lowest line of the grid, to the top of the white mark was measured.

![Figure 2](image_url)  
*Figure 2 – setup for the Countermovement jump test and Kinovea video analysis*
**Equipment and set up:** Prior to the test an "X" was marked on the field, using white tape. In line with the center of the "X," a pole was placed. On the pole were three markings, with 50 cm between the top of each marking and 1 m between the top of the highest mark to the top of the lowest mark. These marks were used to calibrate the players jumping height to centimeters. To evaluate the jumping height, a video analysis was performed using the Kinovea software version 0.8.15. For the video recording a Casio Exilim EX-F1, high-speed camera, was used. All records were captured at 300 frames per second.

**Score:** Results were presented in centimeters.

### 2.6.1.2 Modified Abalakov Jump Test


- **Objective:** As with the CMJ, the Abalakov Jump test is proven as a valid and reliable method to evaluate vertical jumping ability within football players. (Rosell, Custodio, Franco-Márquez, & Badillo, 2016) The modified version aimed to develop a more football-specific version of the test. (coordination)

- **Testing procedure:** The players were instructed to stand on the marked "X" and take three large steps backward. From there, the player should take three steps as fast as possible, land on the "X" mark and jump as high as possible by extending at hips, knees, and ankles using arm swing to gain more power to the jump. (Bosco, Luhtanen, & Komi, 1983) Each player got two attempts; the better one was included in the analysis. See figure 3. For analysis of jumping height, same methods were used as in the CMJ. The author performed all analysis.
Equipment and set up: For the modified Abalakov Jump test, same equipment and set up was used as in the CMJ.

Score: Results were presented in centimeters.

Figure 3 – setup of the modified Abalakov jump test and Kinovea video analysis

2.6.2 Agility

2.6.2.1 The Illinois Agility Test


- Objective: To evaluate the player’s agility, the Illinois Agility Test by Getchell was used. (Getchell, 1979) The test has been proven both valid and reliable to evaluate athlete’s ability to accelerate, decelerate and change direction at high speed in field-based sports. (Robert G. Lockie, 2013)

- Testing procedure: The players were instructed to start lying prone in the start gate with their elbows in 90° flexion and wrists in 90° extension, palms touching the grass. Their chin was placed on the starting line, directly below the timing gate beam. At the start mark, the players were instructed to initiate their movement by pushing up from the arms and “break”
the beam of the timing gates with their head. From there, the players ran the course as indicated with a black line in figure 4. Each player was allowed one try at the test unless they made a mistake during the trial. All players were familiar with the test before participation.

Figure 4 – set up of the Illinois Agility test

- **Equipment and set up:** The track was set up as described by Getchell, 10 m long and 5 m wide marked with cones in each corner. Four cones were placed in line at the center of the track, with 3.3 meters between each cone. To avoid confusion in running path, cones were placed at the starting line, 1 m outside the cones marking the track. These cones were intended to mark the start and finish "gates." The track set up and running path is explained in figure 2. A set of Brower TC timing system was placed outside the cones marking the start and finish gates; hence the gate ran across the whole starting line. The height of the sensors was as low as possible, 30 cm.

- **Score:** Results were presented in seconds.
2.6.3 Anaerobic and aerobic (Capacity and Power)

2.6.3.1 5 x 30 meter repeated sprinting ability


- **Objective:** Introduced by Krustrup et al. the 5 x 30 m RSA assesses the player’s ability to perform repeated 30 m sprints at maximum speed with approximately 25 second recovery time. The test aims to evaluate both anaerobic power and endurance. (Krustrup P, 2006)

- **Testing procedure:** Three players ran in each track, starting with a ten-second interval. The players were instructed to start with one foot at the starting line in still stance. At the start mark, they ran as fast as possible through the track, maintaining full speed through both gates, to the blue cone marking the end of the track. Then, the players jogged back to starting position, as shown with a black broken line on figure 5. From the start mark, players had 30 seconds to complete their run, and be ready for the next sprint. This was repeated five times. To ensure top performance by the players, the national team coaching staff was instructed to motivate and encourage players during the test.

- **Equipment and set up:** A 30 m long track was measured out with timing gates at each end. Starting line was marked with a stripe of tape, 1 meter before the first timing gate. Approximately 5 meters behind the second timing gate a cone was placed. The players were instructed to maintain maximum speed until reaching the cone; this was to ensure that all players ran at top speed through the second timing gate. To ensure a sufficient flow through the test, two sets of timing gates were used; Fusion Smart Speed PT and Brewer TC.
system. The gates height was set as high as possible, at 1.15 m. Tracks were placed along the sideline and the midline of the field, with a mutual starting point. See figure 5.

![Diagram of the setup of the 5 x 30 m repeated sprint ability test]

**Figure 5 – set up of the 5 x 30 m repeated sprint ability test**

- **Score:** The results of the 5 x 30 m RSA provides information about the fastest sprint in seconds and fatigue index. (Bangsbo J., Mohr, Poulsen, Perez-Gomes, & Krstrup, 2006) Fatigue index is calculated as the percentile ratio between the time of the first and last sprint. (Glaister, 2008)

2.6.3.2 The Yo-Yo Intermittent Endurance test level 2

- **Reference:** Bangsbo J. (1994)

- **Objective:** To evaluate the player’s aerobic endurance the Yo-Yo Intermittent Endurance Test Level 2 by Bangsbo et al. was used. (Bangsbo & Mohr, 2012)
Testing procedure: The participants were divided into two groups and paired, based on their numerical order. The lowest numbers ran first, ensuring similar rest between tests for all players. The players not running were responsible for registering their partner's score and yellow cards. A judge was placed on each corner of the course, calling out yellow cards and disqualifying players as well as instructing the players with registration for their partners.

The participants started at the starting line (field midline) in a still stance. During the test, the players were instructed to pace themselves according to the signals provided by the audio file. Players received a warning, yellow card, first time not reaching the line or starting before the test signal. After the first warning, players were disqualified for not reaching the line in time for the test signal.

Figure 6 – set up of the Yo-Yo Intermittent Endurance Test Level 2
– **Equipment and set up:** The course set up followed Bangsbo et al.’s prescription. (Bangsbo & Mohr, 2012) The midline of the field was used as starting line; the end of the track was marked with cones 20 m from the starting line. Recovery area was marked with cones 2.5 m behind the starting line. The audio file was an original file, provided by the Icelandic FA, KSÍ. The setup of the Yo-Yo IE2 course is illustrated in figure 6.

– **Score:** Results were presented as distance covered (meters) in the test.

### 2.7 Technical abilities

#### 2.7.1 Kicking velocity

– **Objective:** To evaluate the players kicking velocity with both left and right leg

– **Testing procedure:** The ball was placed on the penalty mark. The players were instructed to take two steps attempt on to the ball and kick it with as much force as possible to the center of the goal, see figure 7. The players got two attempts with the right leg and two with the left leg. Best results for each leg were recorded.

![Figure 7 – Set up of the Kicking Velocity test](image-url)
Equipment and set up: The players kicked an Adidas Conext 15 football with both left and right foot from the penalty mark to the center of a goal. To measure the kicking velocity radar was placed behind the goal net, 1.4 m from the floor. For the evaluation sports radar, SR3600, by Sports Radar was used.

Score: Results were presented for ball velocity in km/h for both legs.

2.8 Statistical analysis

Normality of data was assessed using Shapiro-Wilks test. Data for IAG test and right leg kicking velocity were not normally distributed ($p > 0.05$). Outliers, data point’s more than two standard deviations from the mean value, were excluded from the statistical analysis. Three outliers were excluded from the IAG test and one from the right leg kicking velocity test. To describe the distribution of participant’s by age, body-composition and playing position, a descriptive analysis was performed. To detect differences in player’s age, body composition and physical performance by playing-position a one-way ANOVA analysis was performed, with a post-hoc Tukey HSD test. All results are presented as mean values with standard deviation.

A standard linear regression analysis was performed to describe the relationship between performance in the physical tests and age over the period. To interpret the correlation between variables used, Pearson’s correlation coefficient $r$ was used. The effect size of the relationships was considered as small ($r > 0.1–0.3$), moderate ($r >0.3–0.5$) large ($r >0.5-0.7$), very large ($r > 0.7 – 0.9$), nearly perfect ($r > 0.9$) and perfect $r = 1.0$). (Hopkins, Marshall, Batterham, & Hanin, 2009) All analysis was performed using IBM SPSS Statistics version 24. For all analyses statistical significance was set at $p <0.05$. 
3. Results

3.1 Physical characteristics of participants

The mean age of players was 16.4 ± 1.31 years, ranging from 13.9 years old to 19.0 years old. The group’s mean anthropometric parameters were; height 169.2 ± 6.12 cm, weight 60.8 ± 6.68 kg, BMI 21.3 ± 2.05 kg/m².

3.2 Results by playing-position

No significant differences were found between playing-positions for age or BMI. However, statistically significant differences were found between groups for height and weight.

Differences were found between playing-positions in the 5 x 30 m RSA test for the 30 m sprint time, fatigue index and the Yo-Yo IE2 test. No significant differences were found for Illinois Agility Test Kicking velocity, CMJ or the modified Abalakov jump test. Detailed results for each test are further listed in table 8 and the following sections.
Anthropometric and physical parameters in players according to playing position. F-value, P-value of ANOVA and differences (post hoc Tukey HSD).

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<th>Central defender (CD)</th>
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<th>Central midfielder (CM)</th>
<th>Forward (F)</th>
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<td>Age (years)</td>
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<td>Height (cm)</td>
<td>177.0 ± 4.87</td>
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<td>Weight (kg)</td>
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<td>BMI (kg/m²)</td>
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<td>CMJ (cm)</td>
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<td>M. AJ (cm)</td>
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<td>IAG (sec)</td>
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<td>Fatigue (%)</td>
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<td>6.17 ± 3.20</td>
<td>6.00 ± 1.66</td>
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<td>.013</td>
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<td>YoYoIE2 (m)</td>
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<td>1049.41 ± 331.521</td>
<td>1124.29 ± 320.618</td>
<td>1112.38 ± 299.50</td>
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<td>.008</td>
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<tr>
<td>Kicking velocity</td>
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</tr>
<tr>
<td>Right (km/h)</td>
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<td>81.18 ± 6.85</td>
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<td>F, p</td>
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<tr>
<td>Left (km/h)</td>
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<td>.20</td>
<td>.939</td>
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</table>

M = mean, SD = standard deviation, cm = centimeters, kg = kilograms, BMI = body mass index, CMJ = countermovement jump, M. AJ = modified Abalakov jump test, IAG = Illinois Agility Test, sec = seconds, 5x30 RSA = 5 x 30 meters repeated sprinting ability, m = meters, % = percentage, YoYoIE2 = Yo-Yo Intermittent Endurance test Level 2, km/h = kilometers per hour.
3.3 Physical characteristics by age

The cross-sectional regression analysis showed a significant correlation between age and increased weight ($F_{1,83} = 1.586, p<0.001$) $r = 0.44$, and BMI ($F_{1,83} = 17.295, p<0.001$) $r = 0.41$. No significant correlation was found between age and height ($p = 0.372$).

3.4 Test performance by age

Positive correlations were found between higher age and improved performance for both right and left foot kicking velocity, ($p<0.001$), and the Yo-Yo IE2 test ($p = 0.009$). No correlations were found between test performance and age for other tests. Detailed results for all tests are further outlined in the following sections.

3.4.1 Countermovement jump and modified Abalakov jump test

Neither CMJ ($p = 0.280$) or the modified Abalakov jump tests ($p = 0.456$) were found to be correlated with age.

3.4.2 The Illinois Agility test

No correlation ($p = 0.081$) was found between performance in the Illinois Agility test and age.
3.4.3 5 x 30 m repeated sprinting ability

In the 5 x 30 m RSA, no correlation was found between 30 m sprinting time and age ($p = 0.158$) or fatigue index and age ($p = 0.322$).

3.4.4 The Yo-Yo Intermittent endurance test level 2

Small positive correlation was found with performance in the Yo-Yo IE2 test and increase in age ($F_{1,80} = 7.226, p = 0.009$). Figure 8 describes the correlation between meters ran in the Yo-Yo IE2 test and age.

![YoYo IE2 and Age](image)

**Figure 8** - The correlation between distance covered (m) in the Yo-Yo Intermittent Endurance Test level 2 and age. A small positive correlation was found, whereas distance covered increases with higher age.

3.4.5 Kicking velocity

Positive correlation was found between kicking velocity and older age, for both right ($F_{1,72} = 15.244, p<0.001$) and left leg ($F_{1,73} = 13.856, p<0.001$). Figure 9 describes the correlation between right leg kicking velocity and age.
Figure 9 - The correlation between right leg kicking velocity (km/h) and age. A positive moderate correlation was found between the variables.

Figure 10 describes the correlation between left leg kicking velocity and age.

Figure 10 - The correlation between left leg kicking velocity (km/h) and age. A positive moderate correlation was found between the variables.
4. Discussion

The main findings of this descriptive analysis by playing position revealed differences in anthropometry and physical fitness. Goalkeepers were taller and had higher body mass than all other playing positions except central defenders. Differences were also found between goalkeepers and outfield players in fatigue index and YoYo IE2 performance. No differences were observed in physical fitness between outfield playing positions, with the exception 30 m sprints, where central midfielders were slower than wingbacks. Results by age show a positive correlation between older age, kicking velocity and performance in YoYo IE2 test.

4.1 Physical characteristics by playing position

As suggested by Martinez-Lagunas et al. (2014) players should be categorized into minimum six different playing positions. However, during the categorization of players into playing positions, 13 players were categorized as both external midfielders and external defenders by the national team coaches. Thus, being used to play in both positions. Therefore, a decision was made to categorize players into five different playing-positions, and combine both the external defenders and external midfielders into one external position; wingbacks. This decision was based on a recent report of match-play demands by Datson et al. (2017) reporting that the match-play demands of external positions are generally similar, with no difference between total distance covered, HSR or sprinting distance (Datson, et al., 2017).
4.1.1 Basic anthropometry

A difference was found between playing positions for height and weight, whereas goalkeepers were taller and heavier than all other playing positions, except for central defenders. Central defenders were on average taller and heavier than other outfield players; however, these differences were not significant. These results are in agreement with previously reported anthropometric values within playing-positions of female football players (Haugen, Seiler, & Tönnessen, 2012; Ingebrigtsen, Dillern, & Shalafawi, 2011; Martinez-Lagunas, Niessen, & Hartmann, 2014; Milanovic, Sporis, & Trajkovic, 2012).

However, previously published studies have used a general categorization of four playing positions, whereas in this study external defenders and external midfielders were categorized as wingbacks. Thus, suggesting that there might be anthropometric differences between central and external defenders. Further analysis of this is needed.

4.1.2 Extension leg power

4.1.2.1 Countermovement Jump and modified Abalakov Jump

No differences were observed in either CMJ or modified Abalakov jump test, between playing positions. This is similar to previously reported results in the literature, as no study has reported significant differences between playing-positions in female football (Vescovi, Brown, & Murray, 2006; Haugen, Seiler, & Tönnessen, 2012; Lockie, et al., 2018). To date, most studies investigating jumping capacity within female football have used a force plate and the Countermovement Jump method described by Bosco (Bosco, Luhtanen, & Komi, 1983). An exception from this was reported by Mujika et al. (2009) as they also analyzed active CMJ, allowing free movement of arms (Mujika, Spencer, Santisteban, Goiriena, &
Bishop, 2009). This method aimed to develop football specific test, evaluating the player's coordination at their ability to utilize their power in a match-like situation.

Jumping height was assessed using video analysis, providing valid and reliable information to differentiate between playing-positions within the participants. However, the reported mean values of this study were generally larger than mean values reported in the literature within elite female football players measured with a force plate, making direct comparison difficult.

4.1.2.2 Agility

Similar to results reported by Vescovi et al. (2006) goalkeepers were slower than outfield players (Vescovi, Brown, & Murray, 2006). Arguably, this could be due to the differences reported in match activity profile and anthropometric values of goalkeepers compared to other playing-positions (FIFA, 2016). In contrast with the reported trends of Vescovi et al. (2006) central defenders had better average performance than central midfielders (Vescovi, Brown, & Murray, 2006).

A total of three outliers were removed from the statistical analysis of the Illinois Agility test, two goalkeepers and a central midfielder, as their performance was more than two standard deviations higher than the groups mean value. Weather their performance was due to measurement error remains unclear. However, other physical characteristics such as height, weight and performance in 30 m sprints suggests that their agility might not be optimal.
4.1.2.3 Sprinting

The average time of central midfielders was slower than all other outfield players in a 30 m sprint, and significantly different from wingbacks. A comparison with other studies is difficult as they report four playing-positions and various sprint distances. However, similar trends were observed by Haugen et al. (2012) whereas midfielders were slower than all other outfield players in 20 m sprints (Haugen, Seiler, & Tönnessen, 2012). In their analysis, a differentiation between central and external midfielders is not conducted, which may affect their results.

The findings of this analysis could be explained by the variability of the physical demands between playing positions during match play. As reported from the FIFA World Cup 2015, wide defenders, wide midfielders and forwards had the highest distance covered at high speed 20-23 km/h, and the highest number of sprints, 24-25 per match, compared to other playing positions. Whereas central midfielders covered significantly longest distance at 16-18 km/h, had the highest total covered distance and performed on average 6-7 sprints less than wide midfielders and wide defenders (FIFA, 2016).

4.1.3 Endurance

No significant differences were observed between playing-positions of outfield players for either the 5 x 30 m RSA or the Yo-Yo IE2 test. However, goalkeepers covered significantly shorter distance at the Yo-Yo IE2 test compared to other playing positions and had significantly higher fatigue index than all other playing positions except forwards. Again, this could be explained by the large difference in match activity between goalkeepers and outfield players, with goalkeepers being reported to walk for 68% of each match, spend only
1.3% of each match at high intensity and performing largest number of their sprints between 0-5 meters (FIFA, 2016).

Although not significant, similar trends were observed while comparing outfield playing positions as reported by Bradley et al. (2014) for elite youth players (Bradley, et al., 2014). Wingbacks, central midfielders and forwards covered on average 65-80 m (approximately two laps) longer distance than central defenders in the YoYo IE2 test. This is in accordance with total distance covered during a match, as central defenders have been reported to cover the shortest total distance and perform the lowest number of sprints during match play (FIFA, 2016). Thus, supporting previously established correlation between total distance covered in the YoYo IE2 test and running performance during match play (Bradley, et al., 2014).

4.1.4 Kicking velocity

The assessed mean ball velocity was similar to the velocity reported in previous studies within female football. (Kellis & Katis, 2007) No difference was observed in kicking velocity between playing positions with either left or right leg; however goalkeepers and wingbacks reported the highest average ball velocity with their right leg compared to other playing positions which could be due to the match play demands of their positions; performing goal kicks, long passes and crosses.

4.2 Development of physical characteristics across age groups

By assessing elite female football players across the age of 15 to 19 years old, this descriptive analysis contributes to the limited knowledge existing within this age group. To
date, most studies have assessed players from 10 to 16 years old or compared juniors players to senior players.

4.2.1 Basic anthropometry and power

A positive correlation was found between increased weight, BMI, and older age. These results are in accordance with results presented by Haugen et al. (2012) reporting that players aged 18-19 weight significantly more than players under 18 years old (Haugen, Seiler, & Tönnessen, 2012). Similar results have also been reported by Emmonds et al. (2018) for players aged 14-16 years old (Emmonds, et al., 2018). However, as fat mass was not assessed in this study, it is impossible to conclude if this increase should be attributed to adipose tissue or lean body mass. Thus, despite an increase in body mass, no differences were observed across age groups in power assessments, for either CMJ, modified Abalakov jump or 30 m sprint. As a strong correlation has been established between an increase in lean body mass and power (Ford, et al., 2011), these results suggest that the increase in weight and BMI should be attributed to hormonal changes or adipose tissue rather than muscle mass (Emmonds, et al., 2018). Thus, an assessment of lean body mass is necessary.

4.2.2 Agility

The literature reports a plateau in agility tests performance around the age of 16 (Vescovi, Rupf, Brown, & Marques, 2011). No correlation was found between performance in the Illinois Agility Test and age. However, studies comparing junior vs. senior players have reported better performance within senior players, suggesting further improvement in agility with older age (Vescovi & McGuigan, 2007). Thus, a different approach to data analyzing could reveal differences between age groups.
4.2.3 Endurance

No significant correlation was found between fatigue index and age. This is in agreement with previous reports by Mujika et al., within 11-18 years old Spanish male players. (Mujika, Spencer, Santisteban, Goiriena, & Bishop, 2009) However, the methods used to calculate fatigue index are questionable. As described the fatigue index represents the percentile ratio between the time of the first and the last sprint. (Glaister, 2008) However, comparison of the first and second sprint revealed that 9% of all players ran faster in their second sprint. Same comparison between the fourth and fifth sprint revealed that 53% were slower in their fourth sprint compared to their fifth. Thus, suggesting that calculations of fatigue index in this study are not valid and reliable.

A small correlation was found between an increase in running distance in the YoYo IE2 and older age. This is in agreement with results reported in recent articles using the YoYo tests (Bradley, et al., 2014; Emmonds, et al., 2018; Mujika, Santisteban, Impellizzeri, & Castagna, 2009). However, these articles report comparison between younger players, age 10-16, or juniors (average age 17 years) vs. seniors (average age 23 years). As concluded by Emmonds et al. (2018) it is likely that these increases in aerobic capacity are due to increased training intensity as well as increased match exposure and intensity. (Emmonds, et al., 2018)

4.2.4 Kicking velocity

Similar to recently published research within Brazilian male football players, the results of this study show a moderate positive correlation in kicking velocity with both left and right leg and older age (Vieira, et al., 2018). As concluded by Vieira et al. these results could be
attributed to improved kicking technique obtained with increased practice time and an increase in lower body strength.

4.3 Limitations

There were many limitations to this study. First, as this was a cross-sectional study, with data collected over a 13 week period, the presented development of anthropometry, physical fitness and kicking velocity across age groups should be interpreted carefully. Evaluation of the players training load was difficult as the participants represented 22 clubs with various coaches and schedules. All clubs with a representant at the training camps were informed of the test sessions with minimum two weeks’ notice. However, a total of 10 players participated in a competitive match the evening prior to one of the test sessions, likely affecting their performance as well as increasing the risk of injuries. As these training camps primarily include low load tactical training, an effort was made to control the readiness of players by moving the last test session to the last training of the camps. Future assessments should aim to manage training load of the included players by improving communication with domestic club coaches and conduct the test sessions at the end of each camp if possible.

The methods of testing limited the possibilities of data comparability and interpretations in some cases. An assessment of lean body mass was not performed, making it impossible to conclude if the positive correlation established between age and weight was due to an increase of adipose tissue or muscle mass. The methods used to assess jumping height provided larger values than other studies have reported, making a direct comparison impossible.
4.4 Conclusion

The conclusions of this study were:

1. Goalkeepers were significantly taller and heavier compared to wingbacks, central midfielders and forwards. Central defenders were on average taller and heavier than other outfield players. These results are in agreement with previously reported anthropometry within the population.

2. No differences were observed between outfield players in the physical fitness, with the exception of 30 m sprint where wingbacks were faster than central midfielders. Goalkeepers were slower than outfield players in the Illinois Agility tests, as well as covering significantly less distance in the YoYo IE2 test compared to all other playing-positions. Their fatigue index was also significantly higher in the 5 x 30 m RSA compared to central defenders, central midfielders and wingbacks.

3. No difference was found between playing positions for kicking velocity with either leg.

4. A positive moderate correlation was established between weight and BMI with older age, suggesting an increase in body mass with older age. However, no correlation was established between age and power, such as jumps and sprints. Small positive correlation was established between improved performances in the YoYo IE2 test and older age.

5. Moderate improvement was found in kicking velocity with both left and right leg and older age. These results are in agreement with previously reported research within Brazilian male youth players.
4.5 Future research and practical application

Future research should aim to increase the value of collected data by adjusting the assessment methods and including more tests. A lean body mass assessment will help to explain if the positive correlation between age and weight is due to muscle mass or adipose tissue. An extra set of timing gates, assessing 0-10 m interval could help further establish variability between playing-positions. A different method to evaluate jumping height, such as the use of force plate or a jump mat, would allow a better comparison to other research published within the population. However, as the time provided for the assessment is only 75 minutes, it should be considered that the inclusion of new tests and change of methods must add value to the gathered information and be completed within the given time frame. To establish a more reliable estimation of the development of youth players anthropometry, physical fitness and kicking velocity, a longitudinal study would be ideal; following players’ through their youth national teams carrier.

The findings of this study can be used to provide youth players and their coaches’ objectives for anthropometry, physical fitness and kicking ability during the preseason based on their age and playing position.
Bibliography


