# Anthropometry and physical fitness of youth Icelandic elite female basketball players before and during COVID-19 and three key court positions

by

Sigrún Másdóttir/Vöggsdóttir

Thesis of 30 ECTS credits

**Master of Education in Sport and Health Education**

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Thesis of 30 ECTS credits submitted to the Sports Science Department,

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Co-supervisor: Dr. Jose M. Saavedra

## Abstract

Many reliable and valuable methods are used to assess the physical prowess of basketball players. This study aimed to evaluate the following factors in women's youth national teams based on age group: (i) Compare anthropometry and physical fitness measurements, both before and during the coronavirus (COVID-19) pandemic, (ii) Compare anthropometry and physical fitness measurements in three key court positions (forwards, centers, and guards). Players who took part in the measurements were in the female national teams U-15, U-16, and U-18. Measurements took place in December 2019 and March 2021; 42 participants took part in both. Both measurements were body measurements (height, weight, hug length, and BMI) and physical fitness measurements (10 and 15m sprint, line-run, T-speed changes, transmission from chest pass with a medicine ball throw, vertical jump, and Yo-Yo IR1 endurance test). The assessment of differences between court positions used the previous measurement from December 2019, in which 71 players took part, playing three different key positions on the court, center, forward, and guard. The first anthropometrical test (before COVID-19) compared to the second (during COVID-19) showed that players improved in height, weight, arm length, and BMI. The fitness measurements also showed differences, as players had improved in chest pass with weight, vertical jump, line run, T-speed change, and Yo-Yo IR1 endurance test). The results showed a difference in body measurements (height, weight, and length of arms) for three key court positions in basketball, where centers measured higher, heavier, and having longer arms than forwards and guards. The physical fitness tests showed a difference between a 15 m sprint and a T-speed test between players in different court positions, where guards measured faster than forwards and centers. There was a difference between center-backs and guards in line-running and jumping, where the guards showed significantly better measurements. It can be figured from the results that COVID-19 did not negatively affect the players physical fitness, and moreover that, the anthropometry of the players affects their positions on the court. The results can benefit coaches of the younger Icelandic female national basketball teams.



Keywords: Basketball, elite female athletes, age, anthropometry, physical fitness measurements, COVID-19, key court positions.

## Ágrip

Margar áreiðanlegar og gagnlegar aðferðir eru notaðar til að meta líkamlegt atgervi körfuknattleiksmanna. Markmið með þessari rannsókn var að meta eftirfarandi þætti kvenna í yngri landsliðum háð aldurshópi: (i) Bera saman líkamsbyggingu og hreystimælingar bæði fyrir og á meðan kórónuveiruheimsfaraldurinn (COVID-19) gekk yfir. (ii) Bera saman líkamsbyggingu og hreystimælingar leikmanna í þremur leikstöðum (miðherjar, framherjar og bakverðir). Leikmenn sem tóku þátt í mælingunum voru í kvennalandsliðunum U-15, U-16 og U-18. Mælingar fóru fram í desember 2019 og mars 2021 og tóku 42 körfuknattleikskonur þátt í báðum. Í báðum mælingunum fóru fram líkamsmælingar (hæð, þyngd, faðmlengd og líkamsþyngdarstuðull) og hreystimælingar (10 og 15m sprettur, línu-hlaup, T-hraðastefnubreytingar, sending úr brjósthæð með þyngdan bolta, lóðrétt hopp og Yo-Yo IR1 þolpróf). Við mat á mun milli leikstaða var notast við fyrri mælingu sem framkvæmd var í desember 2019 en 71 körfuknattleikskona tók þátt í henni. Þátttakendur spila þrjár mismunandi stöður á vellinum, það er stöður miðvarða, framherja og bakvarða. Munur á niðurstöðum frá fyrri líkamsmælingunni (fyrir COVID-19) til þeirrar seinni (meðan á COVID-19 stóð) sýndu að leikmenn bættu við sig í hæð, þyngd, faðmlengd og líkamsþyngdarstuðli. Einnig sást munur í hreystimælingunum, þar sem leikmenn höfðu bætt sig í sendingu úr brjósthæð með þyngd, lóðréttu hoppi, línu-hlaupi, T-hraðastefnubreytingum og Yo-Yo IR1 þolprófi). Niðurstöður sýndu mun í líkamsmælingunum á hæð, þyngd og faðmlengd á þremur lykilstöðum í körfubolta. Miðverðir mældust hærri, þyngri og með lengri faðm en framherjar og bakverðir. Í hreystimælingunni kom fram munur á 15 m spretti og T-hraðaprófi milli leikmanna í mismunandi leikstöðum, þar sem bakverðir mældust hraðari en framherjar og miðherjar. Í línu-hlaupi og lóðréttu hoppi kom fram munur milli miðvarða og bakvarða, þar sem miðverðir sýndu mun betri niðurstöðu. Álykta má út frá niðurstöðum að COVID-19 hafi ekki haft neikvæð áhrif á líkamshreysti leikmanna. Einnig má álykta að líkamsbygging leikmanna hafi áhrif á leikstöður þeirra innan vallar. Niðurstöðurnar geta gagnast þjálfurum íslenskra yngri kvennalandsliða í körfuknattleik.

Lykilorð: Körfuknattleikur, afrekskonur, aldur, líkamsmælingar, hreystimælingar, COVID-19, lykilstöður á velli.

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## Table of Contents

# List of figures

## List of tables

## List of abbreviations

BMI - Body mass index

Cm - Centimeter

CMJ - Countermovement jump

Km - Kilometer

m - Meter

RU - Reykjavík University

$HR_{max}$ - Maximal heart rate

KKÍ - The Icelandic basketball Association

PCR - The phosphocreatine

SD - Standard deviation

U-15 - Icelandic national team under 15 years old

U-16 - Icelandic national team under 16 years old

U-18 - Icelandic national team under 18 years old

VJ – Vertical jump

Yo-Yo IR1 - Yo-Yo Intermittent recovery test level 1

## Introduction

Basketball has grown worldwide as a team sport. Famous and fascinating players with its dynamic characteristics spectators make this sport fun to watch for the fans (Garrett & Kirkendall, 2000). The game of basketball, as one of the most popular sports in many countries worldwide has established itself over the years (Lidor et al., 2007). In every regional basketball championship, the winning teams are identified by specifics, thus defining the performance profile technical-tactical performance indicators (TTPI) in each of its situational variables according to competition (Liu et al., 2015). That means basketball is a dynamic sports game that is played differently in each region of the world. Although it is all over the same sport, playing tactics are different between continents. The game is played by the same rules and the determinants of success or failure are mostly up to the players (Ibáñez et al., 2018). Madarame (2018) monitored a women's championship contest in 2017 (to identify Africa, America, Asia, and Europe). The study showed that women’s basketball games are played differently in each region of the world. However, the European and Asian championship was similar. Furthermore, the homogeneity of the American championship has similarities with the African championship, whereas other ethnics have similarities with the European championship. These findings indicate that basketball games are played differently in each continent (Madarame, 2018). Basketball training methods aim to achieve results through the development of the sport. Before the operational stage in training technology, coaches need to acknowledge the athlete’s skills, abilities, and characteristics on which the result of the sports depends. If this is unknown, the basketball training process can be inefficient and become a stochastic processes (Zaric et al., 2020).

# 1. Basketball background

## 1.1 Basketball

According to Cantwell (2004) first, women's basketball game was played in Springfield, Massachusetts, in 1894. At that time, women were not believed to endure the physical element of sports like men. Therefore, the rules were adjusted for the women's game. The dribble added to the women's game in the 1950s. However, only *a one-time* dribble was allowed. Men's basketball became a part of the Olympic Games in Berlin in 1936 (Cantwell, 2004). Women's basketball was not approved until 1976 for the Montreal Olympic Games (Grama et al., 2015). When women's basketball was approved for the Olympic Games, the rules changed. They became more similar to regulations in men's basketball (Cantwell, 2004).

The best national basketball teams take part in their continental championships. They can also participate in two worldwide competitions, the World Championship, and the Olympic Games. In the last few years, the top team's positions in the medal tables come from the same continental championships (FIBA America and Eurobasket) (Ibáñez et al., 2018). Elite basketball players, both females, and males usually practice daily. Some practice twice a day and play up to two games a week. The players who have been chosen to play for their national team also take part in international tournaments such as Continental, World Championships, and the Olympic Games (Lidor et al., 2007).

Various national teams regularly participate in European Basketball. Championships are held every two years and in international basketball events such as the Olympic Games and World Championships. As a result of this national, continental, and global activity, elite European basketball players play up to about 60 games during the competition phase of the season (Lidor et al., 2007). Icelandic basketball players, female and male, have the mean train of 4.89 days a week and competition 23.29 in a year per season (Saavedra et al., 2018). Various training programs over long term and short term have to be carefully thought through and well planned with this intense schedule in mind (Ziv & Lidor, 2009). Over the past 15 years, many changes have occurred in the game of basketball. Most of these changes relate to the rules and playing styles. This results in a different emphasis on the player's physique and skills. When developing athletes, today factors such as functional and structural characteristics must be considered (Ackland et al., 1997).

### 1.2 Anthropometry of basketball players

The game of basketball has evolved to prioritize player's physical fitness and body size more than before (Ackland et al., 1997). A player's height and physical fitness significantly impact his position on the field and his responsibilities in the game. The physical demand's nature of today's game requires players to have an excellent level of fitness (Drinkwater et al., 2008).

Ercullj & Bracic (2010) studied the morphological characteristics of 68 14-15 years old female players from 26 European national teams during the European Championship the years 2008-2009. For comparison, they were divided into three groups: A, B, and C, depending on their national team's league and their different training and playing experience. Players in group A did come from the strongest teams and with the most experience. Group C included players from weaker teams and players with less experience, and group B had players situated between groups A and B. A total of 31 guards were studied, 20 forwards and 17 centers took part in the study. The conclusions showed that elite centers were on average 184 cm tall, approximately 8 cm taller than forwards, and twice that much taller than guards. The individual differences were significant when looking at their weight. Body Mass Index (BMI) (kg/m2) was measured, and centers had the highest BMI of 26.5, forwards were at 24.1, and the guards had the lowest BMI of 23.4 (Erculj & Bracic, 2010).

Ackland et al. (1997) studied 168 basketball players. The aim was to find different characteristics of World Championship female basketball players. The objective was to establish the absolute relative size, such as height, weight, somatotype, relative size, aerobic profile, strength, anaerobic power agility, and speed. The conclusion showed that elite female basketball players fall into three distinct morphological groups based on differences in total size between guards, forwards, and centers. However, in terms of proportionality (particularly concerning the upper body dimensions), forwards and centers exhibited some similarities. Additionally, guards were shown to differ in characteristics to possess and the varying roles of each playing position within the team. The relative ranking of team performances separates better performers from the poorer ones, especially for the guards and forwards (Ackland et al., 1997). According to Ziv & Lidor (2009) differences in physical attributes and skills can be found when various positions on the field are monitored. For example, players who play as guards tend to be lighter, shorter, and less muscular than players who play as centers (Ziv & Lidor, 2009). According to studies, successful teams tend to have taller players as well as players with longer arm span (Ackland et al., 1997; Carter et al., 2005). A study on female players showed that the percentage of body fat (%BF) was higher in players who play as centers than in the ones who play as guards. On the other hand, players who play as centers measured higher when their fat-free mass (FFM) was compared to FFM of players who played as guards and as forwards. Differences in player's total body weight can explain these findings (Lamonte et al., 1999; Smith & Thomas, 1991).

In a study by Pion et al. (2018) where 150 Belgian male basketball elite players were divided into five positions on the court: point guard, shooting guard, small forward, power forward, and center. A modern basketball depends heavily on these five different positions. Utilizing the proposed position-specific anthropometry could help coaches to get players at desired performance skill. The positions could be determined by these predictive classification models of basketball players (Pion et al., 2018). It is the most common way to classify basketball players into three positions as guards, forwards, and centers (Alejandro et al., 2015; Carter et al., 2005; Delextrat & Cohen, 2009).

According to Ziv & Lidor et al. (2009) to develop an effective training program for athletes, the athlete needs to be monitored and tested by several professionals from different fields. These professionals gather appropriate information from the athletes. Professionals such as basketball coaches, athletic trainers, strength and conditioning coaches, physiotherapists, and sports physicians find specific characteristics in each athlete. This information allows the professionals, all together, to develop a successful and specific training program. The programs are either set out on a daily or weekly basis and as long-term or short-term plans. Well-developed plans are the key for coaches to improve the quality of training and creating a good player (Ziv & Lidor, 2009).

Carvalho et al. (2019) examined the influence of training performance of 38 female basketball players in Brazil. The athletes were monitored for two years (aged 13.38 ± 1.25 years at bayside). They were measured three times per season in anthropometric and physical tests, Line-drill (LD), Yo-Yo intermittent recovery (Yo-Yo IR1), and countermovement jump, and the overall index was estimated. The conclusion of their research is that to develop functional performance across adolescence in female basketball players, accounting for the influence of growth, maturation, and training on competitive basketball performance, coaches need to acknowledge chronological age (CA), biological age (BA), sport age (SA), and training experience of their trainees. Coaches, sports scientists, and others involved in selecting and developing youth basketball players need to recognize that there is no need to artificially manipulate youth competitions to accelerate gains. Youth players will reach their peak and flat their improvement curve at some point (Carvalho et al., 2019).

### 1.3 Measurements and physical fitness testing

According to Lidor et al. (2005) Testing young athlete's abilities is one of the most important fundamentals in any multistep sports program. In most ball games, coaches identify and develope their programs regularly. Successful coaches test physical and technical skills and rely on those tests for program making. These tests should be sports specific. Also, they need to be precise and reflect both on the physical and cognitive aspects of the sport. A greater understanding of the tests enables coaches to be more confident in their decisions-making specific training programs (Lidor et al., 2005). Drinkwater et al. (2008) found that the importance of body size and fitness in basketball may be apparent. However, the sport is highly dependent on basketball-specific skills. The fittest and most prominent players are not always the ones who have the most skills. The physique of a basketball player can be crucial when it comes to choosing a position to play. However, physical demands on basketball players, physical strength, and endurance are also significant (Drinkwater et al., 2008).

Hoare (2000) measured 125 male and 123 female junior basketball players competing at the Australian under 16 championships. Coaches rated player's performance in anthropometric and physiological variables while competition was ongoing and compared performance profiles across playing positions (the best ones and others). The scores indicated good alignment between the testing and the coaches ranking in two out of five positions for males and four out of five positions for females (Hoare, 2000). Hoare found junior basketball, anthropometric and physiological profiling can contribute to selection procedures, but many other factors determine success. Success in team sports is thought to be more dependent on skills, and game strategies acknowledge performance characteristics. Therefore, it is believed to be more difficult to find potentially talented team sport athletes. Basketball is a complex technical game, and differences in performance between players of various ability have been anthropometrically and physiologically identified (Hoare, 2000).

When testing athletes at a young age, tests need to reflect the game's requirements. For the tests to be helpful for coaches, they need to be accurate. The coaches need precise information about the athlete's primary ability. With that information, coaches can also track the athlete's improvements (Drinkwater et al., 2008). The coach's main concern in this phase is to determine whether the young athlete fulfills the basic requirements of the sport. The coach's preference is to evaluate the young player's physical abilities required for a specific sport. In basketball, like said above, these abilities are endurance, speed, strength, flexibility, agility and accuracy (Drinkwater et al., 2008; Falk et al., 2004). In many cases, the young athlete's physical abilities do not necessarily reflect the sports in which the young athlete is involved (Falk et al., 2004). Coaches need to be careful not to put too much exercise pressure on young athletes. Rather coaches should give them time to develop their talents that might otherwise create injury risks or other consequences for young athletes (Baker et al., 2018).

### 1.4 Physical demands in basketball

Basketball is an intermittent-type sport characterized by a high rate of high-intensity actions creating a considerable metabolic and physiological overload (Chatzinikolaou et al., 2014; Draganidis et al., 2015; Narazaki et al., 2009). According to Abdelkrim et al. (2007) after one of the rules changed in 2000 the attacking time decreased from 30 seconds to 24 seconds. The duration of time allowed to cross the median line was reduced by two seconds, from ten seconds to eight. Furthermore, the game's interval changed into four 10-minutes quarters instead of two 20 minutes halves. It affected the tactical and physical demands of the game and had modification being a higher intense game, especially for guards. Therefore, identifying modern basketball's physiological requirements is essential to prescribe and develop an appropriate physical training program for basketball players (Abdelkrim et al., 2007).

In general, the game requires high-intensity activities such as jumping for rebounds, blocks, shots, turns, dribbles, sprints, and screens. As well as low-intensity activities such as walking, stopping, and jogging. Frequent breaks in basketball games allow players to recover between sessions of action, therefore allowing repeated high-intensity periods of play (Drinkwater et al., 2008). Abdelkrim et al (2007) found each player performs about 1050 repetitions of different activities throughout the games. Shorter workouts last for around two seconds and are performed differently among field positions. 18 players were monitored, the six guards accounted for 1103 repetitions, six forwards made 1022, and six centers made 1026 repetitions (Abdelkrim et al., 2007). According to Ziv & Lidor et al. (2009) high-intensity movements tend to be more frequent within guard positions than forward and center positions (Ziv & Lidor, 2009). In a study, female competitive basketball players were evaluated. Heart rates (HR) were obtained on each player for at least one-quarter of played games. The guard’s HR was measured at 154 beats/min to 195 beats/min in a game. This signifies the range of average caloric expenditure of 7.1-11.8 Cal/min, (McArdle et al., 1971). Porters et al. (2020) presented a study where external loads (EL) were measured using a local positioning system and microsensor technology to determine the total, high-intensity (14–21 $km \cdot h^{-1}$), and sprint (>21 $km \cdot h^{-1}$) (Seraphine, 1995, as cited in Portes et al., 2020). The distance between 25 elite junior males and 48 players was compared during 11 competitive games. When EL was compared between sexes, overall males covered larger ($p < 0.05$) high-intensity and sprint distances and completed more ($p < 0.05$) decelerations than females. Female players experienced a more excellent ($p < 0.05$) ratio of accelerations:decelerations. The EL was affected by playing position, mainly when high-intensity and acceleratory movements were in demand. Knowing EL at the elite level, improvements and development in junior basketball players can be more purposeful. Gender and position-specific training programs are more accurately achieved from this knowledge (Portes et al., 2020). According to 25 basketball articles published in 2017, physiological response concentration exceeds the lactate threshold. During live playing time across basketball players, 40-min matches both males and females travel 5–6 km on average. Also, the physiological intensities above lactate threshold and 85% of HR max, guards. Variations in activity demand likely account for the higher blood lactate concentrations and HR responses observed. Guards tend to sprint more frequently and do more high intensity shuffling in a competitive game than forwards and centers. Furthermore, guards tend to walk and stand less during a match compared to forwards and centers (Stojanović et al., 2018). When training, there is always an interaction of physical, technical, tactical, and psychological factors. These four crucial training elements need to be addressed for the quality of the workout. These elements can define the athletics goal, the quality of the workout, and the athlete's contribution (Blumenstein et al., 2005). The physical demands of basketball vary between different levels. The demands are less at younger levels and increase with higher age. Coaching strategies also affect the level of physical demands (Carvalho et al., 2011).

#### *1.4.1 Endurance*

Endurance is divided into two types, aerobic and anaerobic endurance, and the human body's ability to work for a long time and can be. Aerobic endurance is the ability to work for a long time with low intensity. In contrast, anaerobic endurance the body's ability to work for a shorter time with high intensity (Larry et al., 2015). Performance is strongly associated with oxidative capacity, glycolytic rate, removal of lactate, other metabolic by-products, along regulation of ion homeostasis (Bangsbo et al., 1995).

Basketball primarily requires an anaerobic metabolism and is considered an intermittent high-intensity sport (Castagna et al., 2009; Hoffman et al., 1999). Basketball also requires an anaerobic contribution for tactical moves such as defensive and offensive transitions and technical actions such as shooting, jumping, blocking, passing, and lay-ups (Castagna et al., 2010; Delextrat & Cohen, 2008; Hoffman et al., 1999). However, periods of a basketball game (40-48 min) require a high level of aerobic metabolism. Because of the game's length, the players need to have the ability to create phosphate, to clear lactate from active muscle and remove accumulated intracellular inorganic phosphate (Glaister, 2005). With that in mind, it is clear that the physical fitness of basketball athletes and their game performance is influenced by aerobic and anaerobic metabolism (Montgomery et al., 2010; Narazaki et al., 2009). Therefore, interactions that are essential between aerobic and anaerobic metabolism need to be considered in the evaluation, testing, and training processes (Abdelkrim et al., 2010; Balčiūnas et al., 2006; Delextrat & Cohen, 2008). Jumps and sprints are two major basketball activities. These types of activity stimulate the development of anaerobic metabolic processes (Gacesa et al., 2009). In team sports such as basketball, the capacity of aerobic endurance is also a significant performance factor. It increases the ability to recover and maintains the athlete's ability to complete numerous sprints throughout the game (Ciuti et al., 1996). Maximum aerobic capacity (V02 max) in an athletes group is insufficient to differentiate those with the highest aerobic aptitudes and those with the lowest (Lidor et al., 2005). The Yo-Yo intermittent recovery test IR (Yo-Yo), that is the two speed versions of it, have become two of the most used extensively studied fitness tests in sports science due to their specificity. The tests have also been widely applied in other team sports because of practicality to assess player's abilities to repeatedly perform a high-intensity exercise (Bangsbo et al., 2008). This test incorporates accelerations and decelerations in a consistent and reproducible fashion. Athletes should be adequately familiar with this test before going through it. That will ensure valid assessment of intermittent endurance capacity (Papanikolaou et al., 2019). Anaerobic loading is significant during the high-intense periods of a basketball game. Cardiovascular loading, as well as muscle and blood responses, do indicate the mobilization of all energy systems. Energy systems such as oxidative phosphorylation, the ATP- phosphocreatine (CP) system, and glycolysis are all in use (Krustrup et al., 2006; McInnes et al., 1995; Mohr et al., 2016). Also is the line-drill test (LD) has been proposed as a viable and practical anaerobic performance test for basketball players field environments (Semenick, 1990).

According to Carvalho et al. (2019) young female basketball players should be examined at puberty age in Yo-Yo intermittent recovery level 1 (Yo-Yo IR1). The decline is prone to start two years after puberty in Yo-Yo. Older athletes showed more improvements at the beginning of the season and until the end of the season when performing the Yo-Yo test. Compare to Line-drill (LD), progress gradually slows at that same period in an athlete's lifetime (Carvalho et al., 2018; Leonardi et al., 2018).

### *1.4.2 Power*

Maximal aerobic power is measured by maximal oxygen consumption. It has been studied with various methods (direct and indirect). Maximal aerobic power is often used as a synonym for "*fitness.*" Even though anaerobic work is critical in many sports, not much attention has been paid to anaerobic tests (Bosco et al., 1983).

Basketball is a mix of intermittent actions, technical, and tactical demands dependent on explosive- and intercalated strength. In a competitive game an athlete will have to go through high intensity periods with shorter periods of recovery at low intensity (W. B. Young et al., 2002). In many sports, such as football or basketball, players need to respond quickly to the opponent's actions. In these types of sports it is essential to be able to respond instantly with a pre-planned movement called change of direction (COD) and affects the player’s perception and decision making (Young & Farrow, 2006).

According to Narazaki et al. (2009) physiological demands on females and males are similar. They studied 12 athletes, female, and male (average 20.4 years old). The athletes were monitored for 20 minutes in a game. They spent 34.1% of their playing time running and jumping, 56.8% walking, and 9.0% standing still. Both female and male players demonstrated similar movement patterns during a game. About one third of the game was relatively high-intensity, where athletes where either running or jumping. In contrast, more than half of the game, the athletes walked. Furthermore, about 10% of the time players stood still. On average, the players jumped 16-17 times during those 20 minutes they were monitored. The duration per movement was roughly 4.0-4.5 seconds for a run and 5.5-6.0 seconds when walking. These findings may be helpful for coaches to develop sport-specific training programs or drills for practices (Narazaki et al., 2009).

Studies by Rodríguez-Alonso et al. (2003) suggest that player’s physiological characteristics are different according to their field position and role. A total of 25 elite females were measured in 12 games. The conclusion showed that the metabolic load experienced during a basketball game varies according to the player’s position on the field. Female players, at national and international levels, were monitored and showed significantly higher blood lactate concentration levels. Higher average heart rate (HR) was recorded in guards than in forwards and centers. Therefore, the coache’s specific development needs to acknowledge players position (Rodríguez-Alonso et al., 2003).

As a predominantly anaerobic sport, basketball is a high-intensity activity where most of the energy demand comes from changes of direction, jumps, and shots, and the energy comes from the creatine phosphate system (CP) (Metaxas et al., 2009). Two types of throws, free throw (FT) and three-point shots (3S), are very complex basketball fundamentals. In a study of basketball players they performed both free throw and three-point shots under very different conditions in a competitive game (Padulo, Attene, et al., 2015). Ardigò et al. (2018) observed 24 male athletes in U-17. The findings suggested that 50% HRMAX (50HR) does not significantly decrease in 3S, however, while a max heart rate of 80% HRMAX (80HR) significantly does when reducing the performance at 3S compared to resting heart rate (0HR). Coaches should consider different metabolic conditions and the affect of relevant basketball fundamental when training in requirements of moderate-to-high fatigued state, thus a high 3S% can maintain during game-play (Ardigò et al., 2018).

Padulo, Attene et al. (2015) studied the resting heart rate and two different %HRMAX values when athletes performed a free throw shoot (FTs) standard (4.6 m, FTs line distance) and participants were 28 male U-17 basketball players from different teams in Italian National Basketball Championship. Their finding showed that there was no difference within various HRs metabolic intensity processes. Sessions included 10 FTs with 5-sec rest between each shot with a 50HR and 80HR. 80HR FTs successful percentage decreased by 23% from 0HR to 80HR ($P < 0.001$) and by 22% from 50HR to 80HR ($P < 0.001$) (Padulo, Attene, et al., 2015).

### *1.4.3 Speed*

Speed is a crucial ability for endurance and can affect performance in a variety of sports. These abilities are related and dependent on the athlete's muscular strength, mainly on integrating speed, agility speed, and endurance speed (Bomba & Carlo, 2018). A study by Bangsbo (2015) shows how intensified training, i.e. increasing aerobic high-intensity and speed endurance training, affects trained subject’s physiological adaptations and performance. Periods of speed endurance training lasting from 30 seconds to 4 minutes improve performance. When combined with aerobic high-intensity sessions, performance account for more extended and intensive events. Athletes in team sports involving intense exercise actions and endurance aspects, such as soccer and basketball, can also benefit from intensified training (Bangsbo, 2015). Numerous basketball players' short sprints to follow a player might occur in successive different directions during the offense. The player then moves laterally outside the three-point line or defense when a defender follows the offender's actions or during man-to-man (Padulo et al., 2016). According to Stojanovic et al. (2018) guards tend to perform a higher percentage of playing time sprinting and completing high-intensity shuffling than forwards and centers (Stojanović et al., 2018). All players should train speed, and they should practice speed regarding their court positions over short distances and also strengthen their lower and upper bodies (Delextrat & Cohen, 2009).

Furthermore, athletes who perform on a higher level have a more significant intermittent workload than those on a lower level. Geographical differences also may exist when looking at activity demands. Australian athletes have been shown to sustain higher workloads when measuring distance, frequency, and physiological responses than European and African basketball athletes (Stojanović et al., 2018).

A study of time-motion analysis by Abdelkrim et al. (2007) has reported that basketball players perform repeatedly short sprints during the match (Abdelkrim et al., 2007). Thus suggesting that success in basketball participation appears to be primarily dependent on anaerobic metabolism and abilities of the players (Padulo, Laffaye, et al., 2015).

#### *1.4.4 Agility*

Many sports, such as football or basketball, need to respond to player's perception and decision-making velocity be as the ability to change direction. Speed in a predetermined motion opponent's actions and actions and it is essential to respond with a pre-planned movement, such as COD quickly (Young & Farrow, 2006). Scanlan et al. (2014) study suggest that cognitive qualities are essential when developing basketball skills. The study's finding suggests that the initial cognitive measures had the most considerable influence on reactive responsiveness in observed athletes. Tests should also incorporate fundamental basketball movements such as shuffling, jumping, lateral stepping, and dribbling in game-like situations. These test components would improve cognitive aspects and help the athlete's performance and development. The T-agility test (T-test) is mainly used in football, handball, and basketball. It can predict the athlete's short response time how quick he is in a change of direction in sports (Pojskic et al., 2018; Sekulic et al., 2017; Spasic et al., 2015). The agility T-test requires high skill movements; it is reliable and highly valid in determining athletes sprinting speed, lower-body power, and agility. The T-test is a great predictor of future sports performance (Pauole et al., 2000).

The T-test agility and line-drill are both basketball-specific, it is impossible to compare results to other sports. Positional differences are evident in both males and females, with the guards being more agile than both the forwards and centers. That is to be expected, given requirements for the nature of the positions (Hoare, 2000). Sheppard & Young et. al (2006) defined an acceptable definition of agility or agility as challenging to find. It could come from many aspects or disciplines within athletics that can affect performance in coordination. Coaches could define agility with how quickly players change their course. A sports psychologist might determine agility at how fast the athlete is working from specific harassment, e.g., vision scanning, decision making, and response to stimuli to change directions involving appropriate motor skills. The definition of physical agility could be requirements such as strength and conditioning (motor learning and technical skills required in agility performance) (Sheppard & Young, 2006).

A study by Delextrat & Cohen et al. (2009) where 30 female players from four top-ranking Division ll in England showed that guards were significantly faster than centers in the agility T-test. The difference measured 6.9%. Additionally, guards performed 7.1% significantly better than forwards in the line-drill run test. Forwards showed 22.1% better peak torque when knee extensors were tested than centers. These results indicate that specialized fitness training needs to be followed depending on the player’s position and role on the pitch. The ability in a line-drill run, single-leg jump, and the t- test various movements must occur with guards (Delextrat & Cohen, 2009). COD agility and speed are essential components in a wide range of activities in sports. Agility, as a skill, has been defined to initiate a direction change in response to a stimulus (Sheppard & Young, 2006). COD ability is the physical component of agility or speed which encompasses linear sprinting, technique, lower-body strength and power, and the ability to decelerate and accelerate effectively (Hewit et al., 2012, 2013; Sheppard & Young, 2006). When measuring COD speed, it is essential to be task specific. Assessing players with task-specific tests will help coaches utilize the information they get from the results. Therefore the quality of training programs will be more accurate (Nimphius et al., 2018).

Young & Willey et al. (2010) studied thirty one semiprofessional Australian Rules football players. The players were assessed by analyzing the mean of eight test of the reactive agility test. The tester's time to display the stimulus to change direction (tester time) was measured as well as the participant's time to respond to the stimulus (decision time) and the time a participant takes to change direction and sprint to the left or to the right (response movement time). Tester's time was 28.0%, decision time 3.6%, and response movement time 68.4% of the total agility time. The best correlation between decision time and whole agility time was r=0.77. The correlation coefficient between the response movement time and real agility time was r=0.59, indicating that the decision-making time was even more influential to agility than the movement that followed the performance (Young & Willey, 2010).

**1.5 Strength**

Strength is defined as the muscle's ability to exert maximal force or torque at a specified velocity (Knuttgen & Kraemer, 1987). Muscle strength and anaerobic power of the lower extremities are neuromuscular variables that influence many sports activities. Despite frequent contradictions in the literature, it may be assumed that muscle strength and balance play a key role in targeted acute muscle injuries (Lehance et al., 2009). The nature of sports requires the athletes to meet the physical capacity given the level of certain strength qualities for the best results (Newton & Dugan, 2002).

Team sports such as soccer, basketball, and volleyball, are characterized by frequent changes in activity patterns, mainly consisting of repetitive high-intensity actions, for example sprints, decelerations, accelerations, jumping, sliding, shooting, and shuffling, interrupted by periods of low-to-moderate intensity or even standing still (McInnes et al., 1995; Metaxas et al., 2009; Mikołajec et al., 2017; Puente et al., 2017).

### *1.5.1 Upper body strength*

It is highly probable that young basketball players with less muscular strength have had to change their shooting techniques. To help themselves with additional movements when it comes to the lateral direction after the three-point line moved backward (Podmenik et al., 2015).

The medicine ball throw reflects the explosive power of the upper limbs. In a study of 126 female handball players 12-13 years old, the results of the medicine ball throw showed that the selected girls of group A threw significantly farther than the non-selected girls (Lidor et al., 2005). Through general values for both females and males or through analysis statistical, new elements arise concerning the pass in basketball. Especially chest pass, it keeps the central part in activity concerning sexes. Overhead pass is also crucial, with more incredible popularity by females (Theoharopoulos, 2010).

In modern basketball dribble, to move the ball quickly from defense to offense has shown to be less effective than before. Passing is now significantly more important for basketball players, than before, and it is the fastest way to get a quick run and a fast break at the offensive team. Therefore, dribbling is now less critical for coaches than before. This development of the game is a result of 24-second regulation (Evangelos et al., 2005).

The technique and accuracy of shots are related to a basketball player's upper extremities strength (Carroll et al., 2001; Kauranen & ZCSiira, 1998; Tang & Shung, 2005; Woolstenhulme et al., 2004). Ahmed (2013) studied 24 male athletes under 18 years old. The conclusions indicated that coaches need to include upper extremity exercise into their training sessions. However trainers and coaches should avoid upper extremity fatigue, it could result in less accuracy when passing the ball (Ahmed, 2013). Santos & Janeira (2008) studied 25 basketball players 14-15 years old. The study's training program improved muscular power levels with medicine ball throw (MBT). Results showed better synchronization of body segments, increased coordination levels, and greater muscular strength/force. These factors also may be related to more effective MBT training. After ten weeks of in-season training program contributing MBT, it was also shown that basketball shooting technique was improved. The experimental group increased by 19.6% compared to the control group who increased their ability by 5.5% using complex training program with resistance, training twice weekly (Santos & Janeira, 2008).

Scanlan et al. (2015) studied Australian basketball players. They were monitored in three competitive games. They study compared games demands on traveled high-intensity intermittent activity between 12 female and 12 male semi-professionals. Procedures quantified player's activity into two predefined movement categories backcourt (BC) and frontcourt (FC) positions. The result showed that females basketball players in FC positions experienced significantly more upper-body activity and more extensive work than male players in FC position (rest ratios) (A. T. Scanlan et al., 2015).

### *1.5.2 Lower body strength*

Being able to jump high is a critical skill in many sports. The jumps can be taken from a standing position by an approached run and double leg take-off. A jump is utilized, and the extent of an arm swing and countermovement jump (CMJ) (Young et al., 1999). A player who can jump high is likely to be more successful in shooting, throwing, and blocking balls (Erčulj et al., 2010). A jumping test, CMJ is suitable to evaluate the power output of the leg extensor of the knee and hip muscles during natural motion. Bosco et al. (1983) provided a simple test for measurement of mechanical power during vertical rebound jump data supporting the time, contact time and calculates the jumping height or leg stiffness (Bosco et al., 1983).

According to Santos & Janeira (2008) CMJ increased in 25 male basketball players age 14-15 by 10.5% in CMJ in ten weeks time in an experimental group. Pre and post-test were performed. The participants underwent a resistance training with plyometrics twice a week along with regular basketball practices. The compare control group actually decreased -7.7% (Santos & Janeira, 2008). In a study by Carvalho et al. (2019) who measured young female basketball players at puberty age in a CMJ, the improvement was fastest when athletes were examined at puberty age. Players at puberty age were compared to adolescents age-grouped individuals (Carvalho et al., 2019; Leonardi et al., 2018).

Stojanovic et al. (2017) results of 16 studies revealed that it could benefit female athletes to apply plyometric training in their program when practicing vertical jumps

(VJ). Performance shows significant for interventions of longer duration of a training program (>10 weeks). VJ had a moderate effect on CMJ (Stojanović et al., 2017). Athletes participating in team sports are required to cut, jump, and sprint in multiple directions. Two elements that influence an athlete's ability to do this effectively are lower body power and dynamic stability (Kovacs et al., 2008; Lockie et al., 2014; Sheppard & Young, 2006). There is a significant correlation between lower body strength and the ability to quickly COD among athletes in various sports (Tramel et al., 2019). According to Ziv & Lidor et al. (2009) improving their VJ is one of the most desired goals of basketball players and is independent of their court position because VJ plays a role when attacking, shooting, rebounding, defending, and blocking. Those movements require a high ability to frequently do a VJ. According to studies, data suggest that basketball players perform on an average of 44-46 jumps during a regular basketball game (Ziv & Lidor, 2009). Therefore it is necessary to emphasize inferior explosive strength training in the periodization (Abdelkrim et al., 2007; McInnes et al., 1995).

Since arm swing is used during a basketball game, choosing a specific vertical jump test is also important. A CMJ with arm swing allowed would be preferable to a vertical jump test, in which arms are held behind the back or at the waist (Ziv & Lidor, 2009). W.B. Young et al. (2002) studied fifteen male athletes aged 18-28 years, who played soccer, basketball, Australian football, and tennis. The participants took part in three sprint tests, all of which include a change of direction. The conclusion indicates that the leg extensor muscles have some importance in a change of direction performance. However, the drop jump should also measure other technical and perceptual factors that influence agility performance. That appears to be significant for lateral COD speed, possibly because of similar push-off actions. (W. B. Young et al., 2002).

### 1.6 Three key court positions guards, forwards and centers

Study by Drinkwater et al. (2008) classified that the five player positions on a basket-ball field were primarily based on body size, fitness, and skills. The *point guard* is mainly responsible for carrying the ball down the court and coordinating the offense. The *off guards, shooting guards*, and the rest of the team, can score long distances.

The *small forward* is a multi-disciplinary player. Player in that position must be capable of executing the skills of almost any other player on the field should need arise. The *power forward* is typically a relatively more significant player, he is responsible for aggressive play close to the basket, such as gaining possession of the ball after a missed shot. Similarly, the *center* is usually the team's most important player as he is responsible for a close-range shooting on offense and defense, coordinating the team (S. Trninić & Dizdar, 2000; Slavko Trninić et al., 1999).

Ackland et al. (1997) studied the size of female players by positions at the 1994 World Basketball Championship has indicated that anthropometric characteristics can help profile basketball players at the elite senior level (Ackland et al., 1997). Spurgeonet et al. (1981) discriminated against three playing positions on the field, guards, forwards, and centers, and the classification based on morphology proportionality differences. Of these three groups, the centers were the tallest and most significant in absolute size, followed by the forwards and the guards. The differences in morphology were more marked between related lower limb length to sitting height, which showed the basketball players to be higher on this measure (long lower limbs concerning trunk height), than members of the average female population (Ackland et al., 1997; Spurgeon et al., 1981).

The position players are set in is determined by looking into specific talents and the player’s body type (Erculj & Bracic, 2010). Players who have a lot of muscle mass and are tall are preferred as centers. Lighter and shorter players are more likely to be set as midfielders and play further from basket (Gryko et al., 2018: Pojskic et al., 2014; Sallet et al., 2005). Gryko et al. (2019) studied 109 elite Poles national basketball players in teams under 14-20. They assessed the anthropometric of body structure. Conclusions showed that assessment could be crucial when recruiting players for the basketball teams. Arm span and body height are two major somatic factors that can predict a good center and guard. Therefore, monitoring an individual's bodily structure, especially body height and arm span, is an essential characteristic for selecting players into positions. This process will be especially crucial in the transition from junior levels to professional basketball (Gryko et al., 2019).

### 1.7 COVID-19 influence on elite athletes

The world is currently facing a severe coronavirus pandemic (COVID-19). Both amateur and professional athletic events worldwide have been stopped, and teams and athletes have had to adopt social withdrawal measures, interrupting their preparation routines for training and competitions (Andreato et al., 2020). The COVID -19 virus epidemic significantly impacted sporting activities (Sarto et al., 2020). Strict guidelines were enforced to reduce exposure and transmission, thereby limiting athletes in training regular physical activity. The disruption caused by COVID-19 presents a challenge to physicians, coaches, and trainers in discerning best practices for a safe return to sports activities (Mulcahey et al., 2021).

In Iceland, sports activities have not been unaware of the consequences of the COVID-19 virus and the fight against its spread. Since the beginning of the virus epidemic, the Icelandic authorities have emphasized curbing the outbreak's spread through screening, infection control, quarantine and isolation, and various social measures (Sigríður Haraldsd. Elínardóttir & Hildur Björk Sigbjörnsdóttir, 2020). In Iceland the first ban for practice because of COVID-19 was set in mars 2020. The second was established in November the same year, and in the end, the COVID-19 halt stood about nearly 20 weeks for most competing sports (Heilbrigðisráðuneytið, 2021). At the end of week 48 of 2020, 3.541 had a diagnosed COVID-19 infection (Sigríður Haraldsd. Elínardóttir & Hildur Björk Sigbjörnsdóttir, 2020). This change causes severe damage to the quality and quantity of training, further distancing the athletes from the reality of their daily activity in the traditional preparation sites and causing uncertainties about the future. Reducing activity for the athletes and thus losing their physical performance, physical, technical, and psychological damage is inevitable. Losing capacity can mean loss of competitiveness in return for competition (Andreato et al., 2020). Because of the COVID-19 pandemic halts in professional and recreational sporting activities athletes must rely on individualized training at home. However, many teams have implemented a home-based training program with online training sessions or video conferences. Unfortunately, the training level is not comparable with the typical practice and game setting (Jukic et al., 2018). The pandemic stoppage of professional athletic events around the world, including sports such as basketball, football, soccer, rugby, baseball, tennis, and recently the Olympic

Games, illustrates that the sports world is also an essential part of this scenario and has a fundamental role in the containment of this situation. Therefore primary challenged sports science professionals and scientists help athletes deal with some of these relevant aspects during this period (Andreato et al., 2020).

## 2. Objectives

The objectives of the current study were:

i. To analyze the difference in basic anthropometric and physical fitness measurements among Icelandic elite female basketball players over the course of 14 months. The first measurements were taken before the coronavirus pandemic (pre COVID-19) and a second set of measurements taken 14 months later when it was ongoing (during COVID-19).

ii. To analyze the difference in basic anthropometry and physical fitness according to three key court positions (forwards, centers, and guards) on the elite competition level in one selected measurement (the first set of measurements (pre)).

## 3. Methods

### 3.1 Study design

The design of the study is carried out in collaboration with the Icelandic Basketball Association (Körfuknattleikssamband Íslands (KKÍ)). The study includes anthropometry and physical fitness testing within Icelandic elite female national team players over fourteen months (from December 2019 until March 2021). The independent variables in study are time, players, and the three positions center, forward, and guard. The dependent variables are findings of the items measure, that is, the results from the testings from each measurement used anthropometry and physical fitness. Table 1 describes the independent and dependent variables.

**Table 1.**

Variables used in the current study.

| Independent variables | Dependent variables |
|---|---|
| Time<br>Players<br>Player's court position | Anthropometry and physical fitness measurements variables:<br>Height, weight, hug<br>BMI (cm, kg, kg/m2),<br>Countermovement jump,<br>with and without hands (cm),<br>Basketball chest pass (m),<br>15 m sprint (split time 10 m) (S),<br>T-Agility Test (S),<br>Line-drill Test (S),<br>Yo-Yo IE2 (kmŸh -1). |

(cm) centimeters, (kg) = kilograms, (BMI) = Body mass index, (m) = meters, (S) = seconds, (km*h -1) = kilometers an hour.

### 3.2 Participants

A total of 121 individuals were asked to participate in this study. All of them are elite female national Icelandic basketball players born in the five years from 2002 to 2006. A total of 115 took part in one or both tests. Six did not take any part because of injuries or sickness. The anthropometrical measurements and the participant's physical testings were carried out twice, first late in December 2019 and early in March 2021. The participants were grouped by age, both times, into the groups defined as under 15 years old (U-15), under 16 years old (U-16), and under 18 years old (U-18). Because of the long time interval between the testings, 14 months, some participant's groups are part of two age groups, one in the December 2019 testing and another in the March 2021 testing. A total of 71 participants of mean age 14.94 ± 1.01 took part in the first testing, and a total of 86 participants of mean age 15.96 ± 1.04 in the second. A total of 42 participants of mean age 16.61 ± 0.79 took part in both testings. Table 2 shows variables of the group's participants that took part in both the testings and the numbers of participants in each national team 2019 and 2021.

**Table 2.**

Number of participants in each national team in both measurements in the anthropometry, and physical fitness testing.

| Team (year of birth) | The total number of players (n) | (%) |
|---|---|---|
| | Anthropometry, physical fitness testing Dec 2019 | |
| U-15 (2005) | 30 | 42.25% |
| U-16 (2004) | 23 | 32.39% |
| U-18 (2003 - 2002) | 18 | 25.35% |
| Total | 71 | 100.00% |
| | Anthropometry, physical fitness testing March 2021 | |
| U-15 (2006) | 37 | 43.02% |
| U-16 (2005) | 26 | 30.23% |
| U-18 (2004-2003) | 23 | 26.74% |
| Total | 86 | 100.00% |

The 42 participants are 53.5 % of the whole sample of 157 participants. A total of 71 of the participants of team's players of three positions, centers, forwards, and guards, were analyzed in anthropometry and physical fitness from the pre-testing in December 2019. Table 3 shows the teams, and the participant's year of birth, that took part in both anthropometry and physical fitness measurements tests.

**Table 3.**

The number of participants in each national team that took part in both anthropometry and physical fitness test in December 2019 and March 2021.

| Team (year of birth) Dec 2019 | Team (year of birth) March 2021 | The total number of players (n) in both testings | (%) |
|---|---|---|---|
| U-15 (2005) | U-16 (2005) | 24 | 57.14% |
| U-16 (2004) | U-18 (2004) | 10 | 23.81% |
| U-18 (2003) | U-18 (2003) | 8 | 19.05% |
| Total | | 42 | 100.00% |

Table 4 shows the year of birth and team of participants that took part in December 2019 in anthropometry and physical fitness test. Their three court positions, centers, forwards, and guards, are listed, and the number of players in each position.

**Table 4.**

The year of birth and team of participants that took part in December 2019 in anthropometry and physical fitness test, their three court positions, centers, forwards, and guards, and number in each.

| Year of birth and team | Centers (n) | Forwards (n) | Guards (n) | Total players (n) |
|---|---|---|---|---|
| 2005 (U-15) | 5 | 10 | 15 | 30 |
| 2004 (U-16) | 0 | 10 | 13 | 24 |
| 2003 (U-18) | 2 | 1 | 7 | 9 |
| 2002 (U-18) | 1 | 2 | 5 | 8 |
| Total | 8 | 23 | 40 | 71 |

## 3.3 Measures

### *3.3.1 Anthropometry and physical fitness testing battery*

The basic anthropometric and physical tests chosen for this study are listed in table 5.

**Table 5.**

The specific categories anthropometric and physical tests measurements of this study.

| Basic anthropometric | Reference | Evaluation |
|---|---|---|
| 1. Height (cm) | 1. Carter, Ross, Aubry, Hebbelinck & Borms (1982) | 1. Body dimensions |
| 2. Weight (kg) | 2. Carter, Ross, Aubry, Hebbelinck & Borms (1982) | 2. Body dimensions |
| 3. Hug (cm) | 3. Ross & Marfells-Jones (1992) | 3. Body dimensions |
| 4. Body mass index (BMI) | 4. Keys & BroŽek (1953) | 4. Relationship between height and weight. |
| Physical fitness | | |
| 1. Countermovement jump: with and without arms | 1. Bosco et al. (1983) | 1. Power (Extensor’s knee) |
| 2. Basketball chest pass | 2. Delextrat and Cohen (2009) | 2. Power (Extensor’s elbow) |
| 3. 15m sprinting | 3. Adapted from Lidor et al. (2005) | 3. Speed |

| | | |
|---|---|---|
| 4. T agility test | 4. Pauole et al. (2000) | 4. Agility |
| 5. Line drill test | 5. Carvalho et al. (2011) | 5. Anaerobic energy system |
| 6. Yo-yo test | 6. Krustrup et al. (2003) | 6. Aerobic and anaerobic energy system |

### *3.3.2 Basic anthropometry*

Participants were asked to remove their shoes but wear their training clothes in this part of the measurements. A scale (SECA 220) was used to measure weight. For height, participants stood in an upright position with heels, shoulder, and buttocks pressed against the stadiometer. The hug was measured with the participant's face up against the wall, with the fingers side to side pressed at the wall on the measuring tape. Measurements were recorded in centimeters. Body Mass Index (BMI) was calculated based on a specific BMI formula: BMI = weight in kilograms (kg) / height in meters 2 (m2) (Keys & BroŽek, 1953). Each participant's height, weight, and BMI were used to assess the body dimensions (height (m), weight (kg), and body mass index (kg/m2). The BMI [weight (kg)/ height2 (m)] was measured to evaluate the relationship between height and weight for each participant (Keys & BroŽek, 1953).

### *3.3.3 Physical fitness testing*

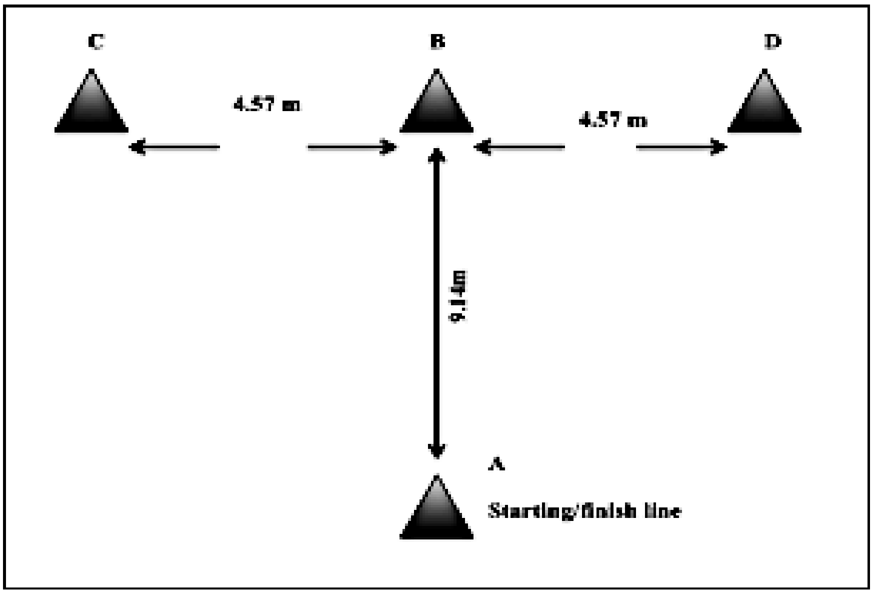
That includes domain tests to evaluate agility T-test, speed 10 m, and 15 aerobic energy system. CMJ 1, CMJ 2, and chest-pass power. Line-drill anaerobic energy system and yoyo aerobic and anaerobic energy system test.

### *3.3.4 Agility T-test*

The T-Test adapted from Pauole et al. (2000) assesses biplanar (frontal and sagittal) agility. The test is set up in a T- like a form that indicates four directions over a 40 m course. The goal is to evaluate how quickly an athlete completes the course. Forward, lateral, and backward movements and three 180° turns and forward weaving through stationary cones over a 60 m course. The participant started one m behind the start gate (A), and ran as quickly as possible forward to the center cone (B), and touched it with the hand, then he proceeded to side-stepped five m towards the left cone (C), and touched it, side-stepped to the left ten m to a right cone (D), and also touched it, then side-stepped back to the right to cone (B), and touched it, and lastly, he ran or moved backward as quickly as possible to cross the finish line to cone (A) (Pauole et al., 2000). The best score was recorded in seconds (S).

**Figure 1.**

*The set up for the agility T-test, adapted from Pauole et al. (2000)*




### *3.3.5 Countermovement jump (CMJ)*

A jumping test adapted from Bosco et al. (1983) suitable to evaluate the power output of leg extensor muscles in the knee and hips during natural motion. The CMJ test was chosen from Bosco et al. (1983) and that provides data supporting the time and contact time and calculate the jumping height or leg stiffness (Bosco et al., 1983). When performing a CMJ, the hands are placed on the hips through the entire jump. When cued, the participants make a countermovement before jumping. However, when free arms countermovement jump is performed, the participants make a countermovement when cued before jumping with arms swinging back during the countermovement's eccentric phase. The goal is to jump as high as possible, but you must land on the jumping mat again. For the jump to be valid, participant's cannot bend their knees or hips in the air (Bosquet et al., 2009). Being able to jump high is a critical skill in many sports like basketball (Young et al., 1999). The highest jump was recorded in centimeters (cm).

**Figure 2.**

*The Countermovement jump with hand on hips (CMJ)*


**Figure 3.**

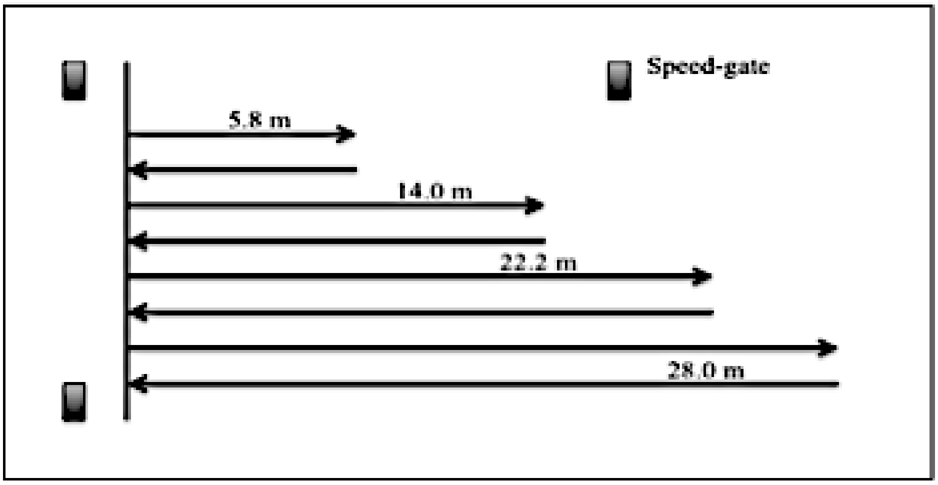
*The Countermovement jump with arms (CMJ)*


### *3.3.6 Line-drill*

The line-drill test adapted from Carvalho et al. (2011) evaluates the anaerobic energy system. The line-drill test (LD) is a viable and practical test of the anaerobic performance of basketball. It has proposed players in field conditions (Tomchuk, 2010). When performing an LD test, the athlete begins the test one meter (m) behind a starting gate. Each participant ran 140 m as fast as possible in the form of four consecutive shuttle sprints of 5.8 m, 14.0 m, 22.2 m, and 28.0 m on a regulation basketball court. The recorded time was by the split gate placed on the baseline where athletes changed directions in the shuttle runs (Carvalho et al., 2011). The time is recorded in seconds (S).

**Figure 4.**

*The set-up for the Line-drill test, adapted from Carvalho et al. (2011)*




### *3.3.7 Sprint 10 and 15 meters*

The 15 m running sprint from Lidor et al. (2005) was used to evaluate the running speed adapted from acceleration. The participants started one meter behind starting gate in a standing position and ran the distance as fast as possible. To measure 15 m a measuring tape was used, and spots were marked at the starting line, at ten meters, and the finishing line (15 m). The participants were forbidden to open the speed gate with hand movement. The speed gate should be open by the trunk at the starting line, and then time is recorded at the ten meters line and finally at the 15 m finishing line. It was important for the speed gates evaluators to make sure the laser line between two gates was precisely on the needed distance line and that there was enough space for the players to run through each gate (Lidor et al., 2005). Each participant had two tries, and the best attempts were used in the analysis. The scores were measured in seconds (S).

### *3.3.8 Basketball chest-pass*

The participants were seated with their head, back, and buttocks against a wall with knees in 90 degrees. Their legs were resting straight horizontally on the floor in front of their body. They were asked to push the ball or medicine ball (3kg) in a horizontal direction as far as possible using a two-handed chest pass. One trial was allowed to become familiar with the gesture; the best of two attempts was recorded. The recording was in centimeters (cm) (Delextrat & Cohen, 2009).

### *3.3.9 Yo-Yo IR recovery test*

The Yo-Yo intermittent recovery test IR (Yo-Yo IR) adapted from Krustrup et al. (2006) has been used as fitness test in some of the most extensive studies in sports science. More practical and specific tests have also been widely applied in many team sports to assess player's abilities to perform repeatedly high-intensity exercises repeatedly. There are two levels of the test. Level 1 (Yo-Yo IR1), being more moderate, and level 1 starts at a lower speed and increases speed more than the level 2 (Yo-Yo IR2) test. The tests consist of 2 × 20m shuttle runs at increasing speeds, interspersed with 10 seconds of active recovery (controlled by audio signals from a compact disc player). The participants had a ten-second rest period between each run. A 20-m-long running lane is marked with cones. The participants run until they are not able to maintain the speed. When the participant failed to reach the finishing line twice, the distance covered was recorded and represented the test result (Krustrup et al., 2006). The test is set up as two lines with cones on each end of the line, with 20 m between cones. While waiting for their turn, participants were regularly reminded to stay warm to decrease the likelihood of injury. It was essential to ensure that the audio system and the Yo-Yo Test-record were loud enough for all athletes and ensured no interruption of the running way. The participants were split into two groups and worked in pairs to help each other fill out the score sheet. Before the test started, participants got instructions, and were guided to repeat 2x20-m runs back and forth. The score measure used in the testing analysis was represented as kilometer/hour (Bangsbo et al., 2008).

**Figure 5.**

*Testing set up in the gym for the Line-drill test and the T-agility test adapted from Hreinsdóttir (2019)*

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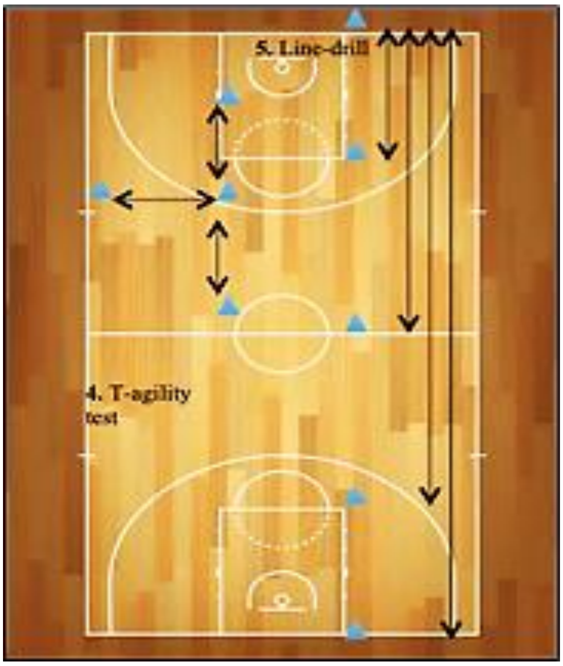
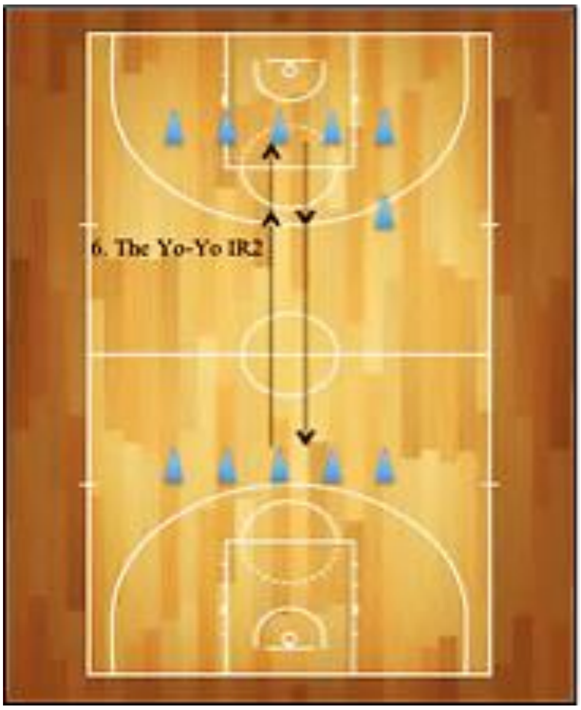



**Figure 6.**

*Testing set up for the Yo-Yo IR2 in the gym adapted from Hreinsdóttir (2019)*



## 4. Procedures

Each national team had one or two evaluation days, and the data on the physical measurements part was collected twice with 14 months between, in December 2019 and in March 2021. The location of the test gym was the same in both tests. The location and the date of evaluation days are shown in table 6.

**Table 6.**

The national teams, dates, and location of the evaluation tests in the study.

| Teams | Date of evaluation days | Gym/location |
|---|---|---|
| U-15, U-16, U-18 | 27/12/2019 | Ásvellir, Hafnarfjörður |
| U-15, U-16, U-18 | 05/03/2021 | Ásvellir, Hafnarfjörður |

A few weeks before the physical testing, the National Teams coaches selected a group of players to participate in the measurements. Therefore, if some individuals were sick or injured, there were some changes of participants between each measurement test session. All participants announced if they experienced any pain, like sickness or injury or stiffness, at the beginning of each testing. If participants were not sure about their health, they should not participate in the testing session. The physiotherapist consulted with the players and coaches from the national team. The best results were used from each testing session to analyze data for each player on all variables. In the gym's first process, each participant lined up in his age team and then received a number to go into smaller groups. Each participant's number was used to record the results of the testing. The best result was written from testing each player on all variables. Except for the line drill and Yo-Yo IR1, they were tested only once. The first part of the measurements was anthropometry, including height, weight, hug, and BMI.

The next session was a warm-up routine for all the players for about 15-minutes. Jogging and jumping require direction changes, so make dynamic stretches, balance exercises, and a few speed cruises and sprints at the end. The warm-up routine was a standardized procedure and was similar in each session time. The next, after the anthropometry and the warm-up, the measurement physical fitness test started. The players were regularly reminded to avoid injury and to stay warm. All the staff encouraged the participants to put their maximum effort into all the tests and gave verbal encouragement for an all-out effort throughout the tests.

The Yo-Yo IR 1 test was performed after the other physical tests were done. When each group was running, another team and assistant staff were calculating in pairs and the total time of each team's testing session varied by the size of each team.

### 4.1 Ethical considerations of the study

All legal guardians of players younger than 18 years old received a formal letter about the research and approval of their adolescent participation in the study. The study was approved by the administrative KKÍ and ethics committee of Reykjavík University and respected the principles of the Declaration of Helsinki.

### 4.2 Statistical analysis

The data was recorded in an excel file examined, and then all regarding statistical analysis performed using IBM SPSS Statistics version 25.0. All the variables in this study satisfied Levene's homogeneity test, for variables were established at $p<0.05$. To compare the mean and standard deviation (SD) a paired–sample t-test was used (pre-test versus pro-test), and it showed a significant difference between group averages. A one-way ANOVA discriminates between the three court positions using the Bonferroni post hoc test.

# 5. Results

## 5.1 The difference in basic anthropometry measurements pre and during COVID-19

Table 7 shows the means, standard deviations, and t-values of the paired-sample t-test, where results from pre and during COVID-19 measurement were compared. Differences were found between all the anthropometric measurements pre and during COVID-19; The participants were taller ($t(41) = -9.601$; $p=<0.05$), heavier ($t(41) = -8.449$; $p=<0.05$) with longer hug ($t(41) = -2.371$; $p=<0.05$) and higher BMI ($t(41) = -4.311$; $p=<0.05$) during COVID-19 than before the pandemic hit.

**Table 7**

Anthropometry measurements pre and during COVID-19.

| Anthropometry | (n) | PRE M ± SD | DURING M ± SD | t-value | p-value |
|---|---|---|---|---|---|
| Height (cm) | 42 | 171.18 ± 6.64 | 173.73 ± 6.56 | -9.601 | 0.000 |
| Weight (kg) | 42 | 64.42 ± 10.51 | 68.47 ± 10.62 | -8.449 | 0.000 |
| Hug (cm) | 42 | 172.58 ± 8.43 | 174.58 ± 7.89 | -2.371 | 0.023 |
| BMI (kg/m2) | 42 | 21.92 ± 2.72 | 22.62 ± 2.73 | -4.311 | 0.000 |

M = Mean; SD = Standard deviation; BMI = Body Mass Index.

### 5.2 The difference in physical fitness measurements pre and during COVID-19

Table 8 shows means, standard deviations, and the result of the paired-sample t-test where there were significant differences, players were better in all cases during COVID-19 than before the pandemic hit. No differences found on the 10 m sprint and the 15 m sprint time pre and during COVID-19. A significant difference found on the line-drill test ($t(40) = 2.375$; *p=<0.05),* T-test, ($t(40) = 5.025$; $p<0.05$), the Chest-pass ($t(40) = -7.025$; $p<0.05$), CMJ with hands ($t(40) = -4.615$; $p<0.05$), CMJ without hands ($t(40) = -3.658$; $p<0.05$) and the Yo-Yo – IR1 ($t(38) = -6.552$; $p <0.05$) ) pre and during COVID-19. Where there were significant differences, players were better in all cases during COVID-19 than before the pandemic hit.

**Table 8.**

Physical fitness tests results pre and during COVID-19.

| Physical fitness | (n) | PRE<br>M ± SD | DURING<br>M ± SD | t-value | Sig |
|---|---|---|---|---|---|
| Chest-pass (m) | 41 | 4.24 ± 0.46 | 4.59 ± 0.45 | -7.025 | 0.000 |
| 10 m sprint (s) | 41 | 1.86 ± 0.14 | 1.88 ± 0.10 | -0.908 | 0.369 |
| 15 m sprint (s) | 41 | 2.63 ± 0.18 | 2.64 ± 0.14 | -0.716 | 0.478 |
| CMJ1 (cm) | 41 | 25.11 ± 4.57 | 26.91 ± 4.35 | -4.615 | 0.000 |
| CMJ2 (cm) | 41 | 29.97 ± 4.61 | 31.78 ± 4.93 | -3.658 | 0.001 |
| T-test (s) | 41 | 10.72 ± 0.62 | 10.45 ± 0.61 | 5.025 | 0.000 |
| Line-drill (s) | 41 | 32.66 ± 1.76 | 32.21 ± 1.82 | 2.375 | 0.022 |
| Yo-Yo IR1 (km*h -1) | 39 | 13.74 ± 0.95 | 14.58 ± 0.97 | -6.552 | 0.000 |

M = Mean; SD = Standard deviation; BMI = Body Mass Index; CMJ 1 = Countermovement jump with hands; CMJ 2 = Countermovement jump without hands; T-test = T-agility test; Line-drill = The Line-drill test; Yo-Yo IR1 = Yo-Yo intermittent recovery level 1.

### 5.3 The difference in basic anthropometry measurements between player's three court positions

Table 9 shows the means, standard deviations, results from one-way ANOVA, and Bonferroni post hoc tests. Differences were found between all the groups in height [F(2) = 20.31, *p<0.01*]. Centers were taller than forwards, and guards and forwards were taller than guards. Differences were found between the groups in weight [F(2) = 11.57, *p<0.01*] and hug [F(2) = 11.39, *p<0.01*]. Centers were heavier than forwards and guards but also had more enormous hugs than the groups mentioned above. No significant differences were between groups in BMI [F(2) = 1.55, *p>0.05*].

**Table 9.**

Anthropometry performance difference between the three player's court positions in December 2019.

| Anthropometry | Center M ± SD | Forward M ± SD | Guard M ± SD | F | p | Difference |
|---|---|---|---|---|---|---|
| | (n=8) | (n=23) | (n=40) | | | |
| Height (cm) | 180.7 ± 3.53 | 171.9 ± 5.38 | 167.5 ± 5.92 | 20.311 | 0.000 | C > F, G ; F > G |
| Weight (kg) | 76.9 ± 13.96 | 65.4 ± 8.40 | 60.9 ± 7.67 | 11.571 | 0.000 | C > F, G |
| Hug (cm) | 182.1 ± 6.24 | 173.4 ± 7.91 | 169.0 ± 7.20 | 11.393 | 0.000 | C > F, G |
| BMI (kg/m2) | 23.55 ± 4.09 | 22.19 ± 3.09 | 21.68 ± 2.21 | 1.554 | 0.219 | N. d |

M = Mean; SD = Standard deviation; BMI = Body Mass Index; C = Center; F = Forward; G = Guard
N.d = No difference.

## 5.4 The difference in physical fitness between between player's three court positions

Table 10 shows means, standard deviation, and results from one-way ANOVA and Bonferroni post hoc tests. No difference was found between the groups in 10 m sprint, chest-pass, and Yo-Yo IR1. Difference was found in 15 m sprint [F(2) = 4.38, p=0.016] and line drill test [F(2) = 4.18, p=0.020] where guards sprint was significantly faster than centers. There was also a difference found between the groups in the T-test [F(2) =7.799, p=0.001], where the guards were significantly faster than both forwards and centers. There was also a difference found between groups in CMJ with [F(2) =3.65, p=0.031] and without hands [F(2) =4.20, p=0.019]. In both CMJ tests, guards jumped higher than centers.

**Table 10.**

Physical fitness performance difference between the player's three court positions in December 2019.

| Physical fitness | Center position M ± SD | Forward position M ± SD | Guard position M ± SD | F | p | Difference |
|---|---|---|---|---|---|---|
| | (n=8) | (n=22) | (n=40) | | | |
| Chest-pass (m) | 4.46 ± 0.69 | 4.21 ± 0.58 | 4.15 ± 0.42 | 1.232 | 0.298 | N. d |
| 10 m sprint (s) | 1.91 ± 0.20 | 1.90 ± 0.14 | 1.81 ± 0.15 | 2.775 | 0.07 | N. d |
| 15 m sprint (s) | 2.74 ± 0.26 | 2.68 ± 0.18 | 2.57 ± 0.17 | 4.382 | 0.016 | C > G |
| CMJ1 (cm) | 21.73 ± 4.22 | 24.38 ± 4.15 | 25.99 ± 4.33 | 3.650 | 0.031 | G > C |
| CMJ2 (cm) | 25.71 ± 4.69 | 29.63 ± 3.56 | 30.54 ± 4.58 | 4.200 | 0.019 | G > C |
| T-test (s) | 11.37 ± 0.47 | 11.00 ± 0.59 | 10.61 ± 0.56 | 4.200 | 0.001 | C > G ; F > G |
| | (n=8) | (n=21) | (n=39) | | | |
| Line-drill (s) | 34.45 ± 1.95 | 33.06 ± 2.04 | 32.49 ± 1.57 | 4.179 | 0.02 | C > G |
| | (n=7) | (n=22) | (n=39) | | | |
| Yo-Yo IR1 (km*h -1) | 13.35 ± 0.78 | 13.61 ± 0.93 | 13.89 ± 0.97 | 1.275 | 0.286 | N. d |

M = Mean; SD = Standard deviation;
CMJ 1 = Countermovement jump with hands; CMJ 2 = Countermovement jump without hands;
T-test = T-agility test; Line-drill = The Line-drill test; Yo-Yo IR1 = Yo-Yo intermittent recovery level 1;
C =Center; F = Forward; G = Guard, † One-way analysis of variance (ANOVA) with Bonferroni post hoc-test was used to compare mean between groups; N. d = No differences.

## 6. Discussion

The objectives of the present study among Icelandic elite female basketball players were: (i) to analyze and compare anthropometrical and physical fitness measurements, in two testings before (pre) COVID-19 and when it was ongoing (during), with 14 months between measurements; (ii) to analyze the difference in basic anthropometry and physical fitness according to three key court positions (centers, forwards, and guards) in one selected measurement the first set of measurements (pre)). Only elite youth basketball females were conducted in this study. The main finding in this study revealed a significant difference between the 42 player’s anthropometry measurements in height, weight, hug, and BMI. A significantly better performance was found in physical fitness in the second set of measurements, during COVID-19, compared to the first set of measurements, previous COVID-19, in Chest-pass, CMJ 1, CMJ 2, line-drill, and the Yo-Yo IR. No difference was found in the 10 m and 15 m sprint, previous versus during COVID-19. There was a significant difference in anthropometry measurements between the key court positions, where centers are the highest, have the most weight, and longest hug, then forwards and last guards. No difference was found in BMI. In physical fitness a significant difference was found in 15 m sprints where guards were significantly faster than centers, and the T-test showed guards significantly faster than forwards and last centers. In line drill, CMJ 1 and CMJ 2 difference was found, guards showed significantly better performance than centers. However, no difference was between the key court positions in chest-pass, 10 m sprint, and Yo-Yo IR1.

### 6.1. Difference between measurements in basic anthropometry and physical fitness pre and during COVID-19

#### *6.1.1 Anthropometry and physical fitness*

With 14 months between the measurements, the first and the second show a significant difference between the players during COVID-19 in all the basic anthropometry, height, weight, hug, and BMI measurements. The players have grown and matured in the 14 months between the first and second measurements. Regarding physical fitness test measurements pre and during COVID-19, there were differences between the analyzed players.

The physical tests show the player's improvements between the two measurements, except in a short speed test in the 10 m and the 15 m sprint. The basketball players were tested in eight physical fitness tests before and during COVID-19. It is interesting and somehow surprising to see that during COVID-19 the players show significant improvement in most of the tests. During this home confinement in COVID-19, athletes must try to perform the technical movements of their sport, although this is limited in many cases due to, e.g., dependence on the opponent, such as team sport's need for equipment or practice location (Andreato et al., 2020). Under these confinement and isolation conditions, athletes were forced to be away from appropriate training conditions, and organized competition, and lacked or had restricted communication with coaches (Tayech et al., 2020). With this in mind, social media platforms through new technologies allow individuals and organizations to share user-generated content and facilitate interactivity (Hayes, 2020). Several researchers and coaches have proposed home training programs to maintain formulated specific recommendations and the physical condition of the general population (Neto et al., 2020).

Therefore, training during home confinement will typically be limited to strength, power, muscle endurance exercises, and general physical preparation (e.g., aerobic training on a cycle ergometer) (Tayech et al., 2020). The conditioning routine during home confinement includes exercises within their physical space possibilities and available equipment (e.g., barbells, weight plates, dumbbells, kettlebells, and bands) (Andreato et al., 2020). Therefore, athletes must remain active to decrease the magnitude and speed of detraining, which should occur due to changes in training routines. In addition, attention should also focus on athletic fitness. (Andreato et al., 2020). To find a similar suspension of the sporting activity, one must look back to the times of the Second World War. For all these reasons by COVID-19, it is a significant challenge for all elite athletes and non-elite (Bisciotti et al., 2020). It can be included in the results in the current study that home training has paid off during different exercises and a ban on competition in times of COVID-19 in Icelandic elite female basketball players.

## 6.2 Difference between the court positions of center, forward, and guard

### *6.2.1 In basic anthropometry measurements*

In this study, anthropometry measurements were analyzed in height, weight, hug, and BMI between the three court positions, guards, forwards, and centers. A significant difference in height, weight, and hug was found between the court positions, centers were the highest with the most mass and more prolonged hug than forwards and last guards. No significant difference was found in BMI within the three court positions. A study from Erculj & Bracic et al. (2010) found that between 68 European national teams, females aged less than 15 years centers were 183.6 cm, the highest, and a significant difference was between the mean size of forwards, 176.0 cm, and then guards, 168.1 cm. No statistically significant differences were found between court positions in BMI (Erculj & Bracic, 2010). These results are similar to those of the current study. A player's size in priority is one of the most qualities specialty and has an enormous influence on a position in the basketball team (Drinkwater et al., 2008).

Ackland et al. (1997) studied 168 players divided into three groups, centers, forwards, and guards from 14 national teams. They were measured using anthropometric dimensions before the Women's World Basketball Championship in Australia 1994. Differences were apparent between mean height: guards were the shortest, 171.9 cm, forwards 181.3 cm, and centers 189.8 cm. The centers and forwards exhibited some similar size measures. In upper body dimensions, arm span was longest in centers,193.8 cm, in forwards 185.0 cm, and guards 176.1 cm. Compared with the current study, there was a significant difference in the hug, where centers show the most extended arm span, 182,1 cm, forwards 173,4 cm, and last guards, 169,0 cm. Also, centers were highest, 180.7 cm, then forwards 171,5 cm and guards smallest 167,5 cm. The combination of height, mass, and ectomorphy provide the best differentiation by position. Despite the apparent size in centers over other players, centers also have the highest body mass. However, no difference was found in BMI in the current study between the positions. Furthermore, this is not surprising since the primary role of the center player in attack (posting up and offensive rebounding) and defense (defensive rebounding) increases the opportunities for vigorous body contact. With guards showing a different proportionality profile compared to either forwards or centers, each position's various functions were considered to explain the findings (Ackland et al., 1997). Gryko et al. (2019) found similar results, the two major somatic factors for basketball player's arm span and body height. That could predict playing positions as center and guard for national team 109 Polish basketball players in all age categories from male U-14 to U-20. The somatic measurements show more significance for centers than forwards and guards and were also more excellent for forwards than for guards (Gryko et al., 2019). This research study and others underline that centers are highest, followed by forwards and most undersized guards.

#### *6.2.2 In physical fitness measurements*

The current study in physical fitness shows a significant difference in three key positions, guards, forwards, and centers, between all three groups in a T-agility test and 15 m sprint. The results show a significant difference in group value between guards and centers in the line drill and the countermovement jump CMJ 1 and CMJ 2. The data in the current study shows no difference between the three groups, centers, forwards, and guards, in physical fitness tests in short 10 m sprint, Yo-Yo IR1, and the chest pass test.

Delextrat & Cohen (2009) studied 30 female basketball players nationally, English League Division ll, between guards, forwards, and centers. The agility T-test result showed that guards were 10.05 s, which is considerably better than centers, 10.74 s. The same study showed no significant difference in short distance sprint and chest pass. The results are similar to those of the current study. According to playing position, these results indicate that specific fitness training must be undertaken for all positions (Delextrat & Cohen, 2009). Hoare et al. (2000) found a similar consistent result in a study of 123 female junior basketball players competing at the Australia Under 16 championship in 1998. No difference was found between all the positions in chest-pass and over the five or ten meter sprint test (Hoare, 2000). Consistent with the current study, no difference was found between the three positions in the chest pass and ten m sprint.

Delextrat & Cohen (2009) found a significant difference between guards and centers in a line drill test. Guards showed 29.5 s and centers 31.9 s, consistent with the results found in the current study in the line-drill test. A significant difference was found between guards and centers in the line drill, where guards showed faster results than centers. There were no differences between the three court positions in the same study in chest pass and 20 m sprint. Similar results were found in the current study. In chest pass, no significant difference was found. A significant difference found in the same study on jump height when the jumping test was on one foot shows that guards jump 43.1 cm, and higher than forwards 37.4 cm and centers 35.4 cm (Delextrat & Cohen, 2009).

The result found in the current study was that guards jump significantly higher than centers in both CMJ 1 and CMJ 2. A similar result was found in a study by Delextrat & Cohen (2008) between eight male player's elite level and eight average levels and shows in the current research in ten m speed performance and found no difference across 20 m (Delextrat & Cohen, 2008).

A study by Legg et al. (2017) of 10 female Australian elite basketball players, from pre- to post-season study with jump height performance, measures occurred stable in all measurement points across the season. They found no substantial changes in jump performance CMJ; however, most effects were reversed by the end of the season, and results showed a significantly higher improvement in CMJ ($p$ = 0.006; 11.7% vs. 6.8%), a slight increase in these measures from the mid-season to post-season study from (Legg et al., 2017).

Jumping is one of the most important movements for basketball players. The measure is crucial to compare the players in all positions on the court and is accessible in practice (Delextrat & Cohen, 2008).

## 7. Limitations

The limitations of this study were several. The length of season competition in the Icelandic division repeatedly changed because of the COVID-19 pandemic and was put on hold for several weeks. The practice volume varies highly between groups in the teams. Because of that, the testing schedules changed, except for the first testing. Also, the groups of centers, forwards, and guards, the three key positions, were not equal by size in all teams. In the second testing in March 2021, the U-15 team was in its first testing session because it did not take part in the first testing. The other groups had moved up into older group teams. Also, the testing schedule did not last between six months or one year, as it was lined up initially.

## 8. Conclusion

The summary of the study compared differences between measurements in U-15, U-16, and U-18, anthropometry, physical fitness testing's pre and during the COVID-19 pandemic, and the three key positions, center, forward, and guard.

### I. Anthropometry of U-15, U-16, and U-18 pre and during COVID-19

The study showed a significant difference between the pre covid and during COVID-19 measurements in height, weight, hug, and BMI in anthropometry measurements between the teams. Considering that there were fourteen months between the anthropometry measurements, the individuals have been growing and changing in all anthropometry measures in this time.

### II. Physical fitness of U-15, U-16, and U-18 pre and during COVID-19

The results show no difference in both 10 m and 15 m sprints. The current study shows a significant difference in the physical fitness test between the pre and during COVID-19 measurements, line-drill, T-test, chest-pass, jumping ability, CMJ 1 and CMJ 2, and Yo-Yo intermittent recovery level 1. The measurements during COVID-19 showed significantly increased results compared to the measurements pre COVID-19, except the 10 m and 15 m sprints, in all the tests. The individuals are thus shown to have trained themselves regarding physical fitness. When the organized exercises within club teams in Icelandic competition stopped the league because of COVID-19 and the athletes individually had to practice on their own or just a few in a group, it can be concluded that the COVID-19 period had a positive effect on the physical fitness of Icelandic elite basketball teams.

### III. Anthropometric measurements between centers, forwards, and guards

Differences were found between measurements in the anthropometry between the three court positions in height, weight, and hug. The centers were the highest, had the most weight and longest hug compared to the other groups, then forwards and last guards. No significant differences were found in BMI between the groups. Anthropometry can predict which position an individual plays on the court in basketball, center forward or guard. Still, the center group was with the fewest individuals, but it seems that the center is a crucial player.

**IV. Physical fitness between centers, forwards, and guards**

No significant difference was found in physical fitness tests in 10 m sprints, chest-pass, and Yo-Yo intermittent recovery level 1. The difference between the three key positions in 15 m sprints and t-test was that the guards were faster than forwards and centers. A significant difference was found between centers and guards in the counter-movement jumps CMJ 1 and CMJ 2 (anaerobic power). The results show that guards jump higher than forwards and centers and run faster line-drill and the agility T-test. The guards had a shorter time than forwards and centers, probably because of less mass and shorter height, and usually performed side shuffles over longer distances than centers and forwards. The guard also has control over the attack, has the most time control over the ballplayer during a game, and has to have a good jump ability to shoot on a long turn. Forwards can be fast and have many skills, be they short or big. The ability to perform the line drill and the different movements involved in the agility t-test should be developed in guards. Strength and power training of the lower limbs should be designed for forwards and centers, particularly explosive power centers. Basketball players in all playing positions should practice fast speed distances and strength development in both lower and upper bodies.

**V.** The current study results give information on how the coronavirus pandemic physically affected the youth female national teams for over a year. Also, comparing the data from the three key positions, guards, forwards, and centers, showed how the players fitted best in those positions. Coaches can use the group's teams data information to improve Icelandic national female team's future competitions.

## 9. Future studies

The results of this study should give the female national team coaches information on how the player's physical condition is compared to the measurement's results. It would also be possible to measure players in a specific position, centers, forwards, and guards, on the pitch when the team plays national matches. It would be essential to follow the player's career from the youngest team onwards, and also it would be an incentive for the players to have long-term data in the national team, from the youngest youth teams and up, and encourage participants.

Future research should examine whether there is a link between increased fitness and performance in the female national teams and how the coronavirus pandemic impacted the individual, and the youth teams, in the long term. Thus, it can be based on player's continued targeted training to improve player's and team's performance in competitions for the female national teams in international tournaments.

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