eman ta zabal zazu

Universidad del País Vasco — Euskal Herriko Unibertsitatea

Facultad de Ciencias de la Actividad Física y el Deporte

Jarduera Fisikoa eta Kirolaren Zientzien Fakultatea

Departamento de Educación Física y Deportiva

Gorputz eta Kirol Hezkuntza Saila

MAILA HANDIKO FUTBOLARI GAZTEEN EZAUGARRIEN GARAPENA ETA EBOLUZIOA

Egilea: Iraia Bidaurrazaga Lopez de Letona

2015

"… y yo no creo que haya que perder de vista nunca, que el futbol es sobre todo una fiesta posible, una fiesta de las piernas que lo juegan y de los ojos que lo miran."

Eduardo Galeano "Un mendigo del buen fútbol"

Esker onak

Orain dela lau urte hasitako bidea bukatzear da. Luzea izan da bidea, momentu on askorekin eta momentu txar bat baino gehiagorekin. Bidean zehar asko izan dira eguneroko lanean lagundu nautenak modu batera edo bestera. Danoi asko zor dizuet eta ez nuke inor ahazterik nahi. Beraz, bakoitzaren laguntza lerro hauetan aipatuta ageri ez bada, bakoitzak berea hartzen jakingo duen esperantza daukat.

Lehenbizi, UPV/EHUko Gorputz eta Kirol Hezkuntza Saila eta Jarduera Fisikoa eta Kirolaren Zientzien Fakultatea eta Eusko Jaurlaritza eskertu gura ditut. Lehendabizikoei eskerrak eman nahi dizkiet ikerlan hau egitea onartzeagatik. Eusko Jaurlaritzari, berriz, tesiari babes ekonomikoa emateagatik eta Coimbrako unibertsitatean egonaldia ahalbideratzeagatik.

Bigarrenik, eskerrak eman nahi dizkiot tesi zuzendari izan dudan Susana Gil Orozkori, hasiera-hasieratik nigan erakutsitako konfiantzarengatik, bere pazientzia amaiezinagatik, unibertsitatean bide egiten laguntzeagatik eta, bereziki, bere laguntasunagatik. Honegatik guztiagatik tesi hau nirea bezain zurea da, Susana.

Hirugarrenik, esanguratsuki eskerrak eman nahi dizkiet Athletic Club futbol taldeko zuzendaritzari eta teknikariei. Batik bat, Josean Lekue-ri eta Markos Amado-ri beti laguntzeko prest agertzeagatik eta haien konfiantzagatik. Oro har, mila esker ikerlanean parte hartu duten futbolari gazteei eta haien familiei ere, ikerketa ez litzateke-eta posible izango haiek gabe. Aupa zuek! Aupa Athletic!

Nire alboan lankide izan ditudanei ere eman nahi dizkiet eskerrak, modu batera edo bestera honako lan hau aberasteagatik. Aduna Badiola-ri eta Cristina Granados-i zuen animo eta aholkuengatik. Lau urte hauetan zehar neurketetan laguntzeko prest agertu zareten Joseba Sesma, Alex Fernandez, Andres Vargas eta Izaro Esain, eskerrik asko. Jaime Zuberori ere eskerrak eman nahi nizkioke, alde batetik, bere tesiko datuak erabiltzen usteagatik eta, bestetik, lan egiteko bere prestutasunagatik. Eskerrak, bereziki, Jordan Santos-i, behar izan dudanean munduaren beste puntatik bidalitako e-mail beti lagungarriengatik eta beti animoak emateko prest egoteagatik.

También me gustaría expresar mi agradecimiento a la Faculdade de Ciências do Desporto e Educação Física y a su director Antonio Figueiredo por darme la oportunidad de realizar la estancia de investigación en la Universidad de Coimbra. Igualmente, me gustaría dar las gracias a Carlos Gonçalves por los trámites de útima hora; también me gustaría agradecer a Fatima Rosado y a Alan Massart el haber contado conmigo durante mi estancia; gracias a Renata Fiedler y a Lú Minuzzi por todos los momentos compartidos y a João Abreu y a la Secção de Judo da Associação Académica de Coimbra por todos y cada uno de los randoris de esos tres meses. Especialmente, me gustaría dar las gracias a Artur Santos y a Humberto Carvalho. Al primero por ser mi guia incondicional durante mi estancia. Al segundo, por su paciencia y tesón en el trabajo. Gracias a los dos por vuestra amistad.

Eskerrik asko, bihotz bihotzez, nire koadrilari (gora gu ta gutarrak!) azkeneko hilabete hauetan erakutsi didazuen baldintzarik gabeko laguntzagatik eta animoengatik. Bereziki, eskerrik asko Mai eta Olaia, ordenagailu aurrean eta gominola artean igarotako sapatuengatik eta astearteak nire asteko egunik gogokoenak bihurtzeagatik. Behar izan dudanean aldamenean hor izan zaretenoi ere eskerrak eman nahi dizkizuet: Maita eta Saio, nire ivefa maiteak, beti nigan sinesteagatik (kafe makinak hau ikusiko balu…), Zarautzeko familia eta koadrila, judoko lagunak, inguruko eta ez hain ingurukoak ere. Tesia zer moduz doan, zer moduz nagoen… galdetzeagatik. Berebiziko babesa eman didazuelako, eskerrik asko danoi.

Bukatzeko, etxekoiei eskaini nahi dizkiet nire eskerrik beroenak beti alboan izan baititut. Eskerrik asko aititeri eta, batez ere, amamari, zure "asko falta jatzu?" guztiek bukatzeko indar gehiago eman didatelako. Gracias a Agus por enseñarme que los retos, dentro o fuera del tatami, se consiguen con trabajo, confianza y esfuerzo. Gracias ama y aita por haberme aguantado a pesar de todo. Por haber estado ahí en los buenos y en los malos momentos. Por enseñarme que la constancia es una virtud. Eta eskerrik asko zuri, Julen. Nigan konfiantza duen norbait baldin badago munduan, hori zu zara. Eskerrik asko zure pazientziagatik, beti ulerkor agertzeagatik eta orain arte konpartitu ditugun eta etorkizunean konpartituko ditugun momentu ororengatik.

And now…the show must go on

Laburpena
Abstract

LABURPENA

HELBURUA: Gutxi dira urteetan zehar eliteko talde gazte baten jarraipena burutu duten ikerketak. Horrela, lan honen helburu orokorra, maila handiko futbol jokalari gazteen ezaugarri antropometrikoak, fisikoak eta fisiologikoak ezagutzea izan zen. Horretaz gain, ezaugarri horiek denboran zehar nola aldatzen diren aztertu zen. Are gehiago, futbol talde profesional batean hautaketa prozesuetan ezaugarri horien garrantzia zein den zehaztu nahi izan zen.

METODOLOGIA: Ikerketan parte hartu zuten jokalariak 1999. urtean eta 1998. urtean jaiotako Athletic Club-eko futbol jokalariak izan ziren. Ikerketa lau denboralditan zehar burutu zen, 2009-2010 denboralditik 2012-2013 denboraldira, alegia. Urtero neurketak denboraldi hasieran eta bukaeran egin ziren. Horrela, zortzi momentu desberdinetan hurrengo neurketak egin ziren: antropometria osoa, errendimendu probak (15-m leun, Barrow trebetasun proba, besoen ekintzaren aurkako jauzia, Yo-Yo Etengabeko Suspertze Testa 1go maila eta handgrip esku dinamometria) eta listu lagin bilketa (testosterona eta dehidroepiandosterona hormonen kontzentrazioren neurketa). Gainera, adin kronologikoa eta adinaren araberako altueraren puntako abiadura kalkulatu ziren.

EMAITZAK: Alde batetik ikusi zen jokalariak nagusitzen ziren heinean hazi egiten zirela eta errendimendu probetan emaitzak hobetu egiten zirela. Hala ere, hazkundean eta proba fisikoetan ikusi ziren aldaketak ez ziren linealak izan. Izan ere, hazkunde eta hobekuntza gailurrak antzeman ziren adinaren arabera. Beste alde batetik, populazio desberdinak konparatzean ikusi zen Athletic Club-eko jokalariak populazio orokorra eta futbol maila baxuagoko futbol jokalariak baina altuagoak eta pisutsuagoak zirela eta gantz gutxiago zutela. Gainera, adin desberdinetan taldetik joaten ziren jokalariak, gelditzen ziren jokalariak eta etortzen ziren jokalariak konparatzean ikusi zen ezaugarriak aldakorrak zirela. Bukatzeko, ikusi zen adin kronologikoak, hazkunde mailak, tamainak eta gantzak eragina zutela proba fisikoen errendimenduan, hots hauen errendimendu maila aurresateko gai zirela.

ONDORIOAK: Jokalariak nagusiagotzen joan ziren heinean altuagoak eta pisutsuagoak bihurtu ziren eta proba fisikoen emaitzak gero eta hobeagoak izan ziren. Horrela, ikusi zen futbol jokalari gazteen hazkundeak eta garapenak errendimeanduan garrantzia zutela. Gainera, jokalarien aukeraketan eragina zuten parametroen artean gorputz tamaina handia eta gantz kopuru txikia izateak garrantzi zutela ikusi zen. Nahiz eta nagusitu heinean errendimentu hobekuntzak ikusi ziren, heltzeak eta hazkuntzak hobekuntza horietan eragina zutela ikusi zen. Zehazki, hobekuntzak ikusi ziren denboraldi guztietan zehar, seguru asko, gorputz tamaina handitzearen ondorioz. Klubaren hautaketa eta progresio prozesuak aztertzean, ikusi zen bai aldagai antropometrikoek eta baita errendimendu parametroek ere aukeratuak diren jokalarien eta aukeratuak ez direnen artean desberdintzeko gaitasuna zutela. Are eta gehiago, ikusi zen prozedura hauek heltze berantiarra eta urte bukaeran jaiotako jokalariak baztertzen zituztela. Ez hori bakarrik, klubean *adin erlatiboaren eragina* ematen zela ikusi zen, hots, jokalarien ehuneko hirugoeita seia urteko lehenengo hilabeteetan jaiotakoak zirela ikusi zen. Bukatzeko, badirudi klubak tamaina handiko jokalariak aukeratzen zituela, helduak eta kronologikoki nagusiagoak zirenak, gantz gutxiago zutenak eta, orokorrean, proba fisikoetan emaitza onenak zituztenak; alegia, talentuak bezala definituak ziren jokalariak.

Hitz gakoak: Futbol jokalari gazteak, heltzea, errendimendua, hazkundea, adina.

ABSTRACT

AIM: Literature regarding the development of young elite soccer players is scarce. Thus, the main aim of the present study was to determine anthropometric, physical and physiological characteristics of high level players; and also to analyze how these parameters change across time. Moreover, we aimed to determine the relevance of the aforementioned parameters in the selection process of a professional soccer club.

METHODOLOGY: The present study involves a longitudinal analysis of the development of performance during 4 years, i.e, 4 competitive seasons (from season 2009-2010 to 2012-2013). Participants were players of the Athletic Club, born in 1998 and 1999. The soccer players were evaluated annually on two occasions: first, at the start of the season; second, at the end period of the training-season. The following variables were measured: complete anthropometry, physical performance tests velocity 15-m (velocity), Barrow´s agility test (agility), Yo-Yo intermittent recovery tests (Level 1), counter-movement jump and hand dynamometry (dynamometry) and salivary hormones concentration (testosterone and dehydroepiandrosterone). Chronological age and age at peak height velocity were calculated.

RESULTS: On the one hand, we observed that as players get older they grew and performed better. However, changes observed in both growth and performance were not linear. Indeed, peaks of accelerated growth were observed. On the other hand, when comparing different populations we observed that Athletic Club players were taller, heavier and leaner than the general population and soccer players of lower level. Also, we found that characteristics were different between players who dropped-out, players who continued and players who entered the club in different age groups. Finally, we observed that chronological age, maturation, body size and skinfolds were predictors of performance in youth soccer players.

CONCLUSIONS: The analysis of different parameters showed that players grow as age increased and, similarly, performance improvements were observed. Thus, the patterns of physical growth and maturation of young players merit more detailed consideration when analyzing performance in young soccer players. Besides, it seems clear that a large body size and a small amount of body fat are relevant anthropometric parameters involved in the selection process of high level soccer players. Although improvements in performance were observed as age increased, the results indicate that changes in performance were significantly affected by growth and maturation. Interestingly, improvements in performance were observed in most of the off-season periods, possibly due to the effects of body growth. However, an evident decrement in performance was observed in the U13 off-season indicating a possible effect of detraining due to the summer vacation at this age. When analyzing selection and progression within the club, we observed that anthropometrical and physical performance characteristics can differentiate between players that are selected from those that are not. Moreover, results demonstrate that these procedures may eliminate late maturer's with potential and exclude players born late. Indeed, sixty six percent of the players were born in the first half of the year confirming the presence of the Relative Age Effect in the club. Finally, it seems that technical staff of the club selects players with a large body size, advanced maturity, and particularly older chronological age and less body fat, who are the best performers; and thus, may be considered talented.

Keywords: Youth soccer players, maturation, performance, growth, age.

Hitzaurrea

HITZAURREA

Hitzaurreek irakurlea nonbaiten kokatzen dute: hiri batean, garai batean edota istorio batean, idazlearen esku egoten da hori zehaztea. Kasu honetan ere, hori lortzen saiatu da idazlea, hots, saiatu da kokagune bat aurkitzen, bidaiari hasiera emateko modu egoki bat aukeratzen. Nondik abiatu? Nondik hasi?

Lan honen irakurketan kokagune edo hasiera bat aurkitzeko, ezinbestekoa da aipatzea tesiaren nazioarteko izaerak nolabait baldintzatu egin duela lan guztiaren antolakuntza. Izan ere, idazlearen hasierako asmoa tesia euskara hutsez idaztea bazen ere, denboraren poderioz nazioarteko tesia egiteko erabakiak indarra hartu zuen. Erabaki horren ondorioz, tesiko atal batzuk euskaraz idatzi dira (hasierako asmo horri eutsiz) eta beste batzuk ingelesez (nazioarteko tesien oinarriak bermatuz).

Lan honen irakurketan eragina duen beste faktoreetako bat lanaren izaera longitudinala izan da. Halaber, datuak estatistikoki lantzea, antolatzea eta, batez ere, era ulerkor batean aurkeztea ez da lan erraza izan. Honek guztiak eragina izan du tesiaren atalak antolatzerakoan eta, ondorioz, lan honek tesi tradizionalen itxura duen arren, ez ditu tesi tradizionalek dituzten ezaugarri guztiak betetzen. Nahiz eta hartutako erabakiak irakurlea asetuko duelakoan gauden, atalez-atal irakurleak zer aurkituko duen zehaztea gustatuko litzaiguke. Hortaz, hurrenez hurren, tesiko kapitulu bakoitzean irakurleak zer aurkituko duen azalduko dugu.

Hasteko, tesi honetan aztergai duguna, hain zuzen ere, “Maila handiko futbolari gazteen ezaugarrien garapena eta eboluzioa” da. Horrela, tesia bederatzi atalez osatua dago.

Lehenengo atalean, sarreran, ikerketa gaiari buruzko errebisio bibliografiko orokorra egin da; bertan dauden datuak ezinbestekoak dira tesiaren nondik norakoak bermatzeko. Gainera, atal hau euskaraz idatzia da.

Bigarren atalean helburuak daude; hots, tesiaren xede nagusia eta helburu espezifikoak zehazten dira. Atal hau, ere, euskaraz idatzi da.

Hirugarren atalean, material eta metodoak atalean hain zuzen ere, proiektuaren diseinua azaltzen da eta, era berean, ikerketan erabili diren proben eta protokoloen adibide zehatzak ageri dira. Atal hau da euskaraz idatzita dagoen azkeneko atala.

Laugarren atalean emaitzak azaltzen dira. Atal honetan, hain zuzen, ez da jarraitu tesi tradizionaletan erabiltzen den ohiko formatua. Horrela, emaitzen atala bost azpi ataletan banatzen da. Azpi atal bakoitzak helburu espezifiko bat du eta, ez hori bakarrik, kasu bakoitzean desberdina da erabili den lagina eta baita metodología ere. Hori dela eta, azpi atalek sarrera txiki bat dute, metodologia propioa eta, baita ere, emaitza, eztabaida eta ondorio propioak. Atal hau ingelesez idatzi da.

Bosgarren atala, eztabaida orokorra da. Bertan, aurretik aipaturiko bost azpi atalen eztabaiden sintesia ageri da; alegia, tesiaren eztabaida orokorra. Atal hau, ere, ingelesez idatzi da.

Seigarren atalean, ondorioak ageri dira. Ondorioetan ageri dira aztergaiari tesiak egiten dizkion ekarpen garrantzitsuenak. Alegia, era zehatz eta labur batean ikerketaren konklusio garrantzitsuenak azaltzen dira. Atal hau ingelesez idatzi da.

Zazpigarren atalean, ikerketaren mugak eta etorkizunerako proposamenak azaltzen dira. Beraz, alde batetik, ikerketan zehar aurkitu diren mugak zehazten dira, batez ere, metodologiari dagokionez. Beste alde batetik, etorkizunerako proposamenetan, tesi honetan aztertu ez diren baina etorkizunean aztertzeko interesgarriak suertatu daitezkeen zenbait aspektu aipatzen da. Azkeneko atal hau, ere, ingelesez idatzi da.

Bukatzeko, zortzigarren eta bederatzigarren ataletan erreferentziak eta eranskinak daude, hurrenez hurren.

Laburdurak

LABURDURAK

APHV	Altueraren puntako abiaduraren adina/Age at peak height velocity.
B	Besoko perimetro zuzendua.
CA	Adin kronologikosa /Chronological age.
CD	Club deportivo.
CV	Aldagarritasun koefizientea/ Coefficient of variation.
DENA	Athletic Club-eko talentu hautaketa proiektua/Talent identification project of the Athletic Club
DHEA	Dehidroepiandrosterona/Dehidroepiandosterone.
EJ	Erorketa jauzia.
ES	Effect size.
F	Belauneko diametroa.
GGM	Gantzik gabeko masa.
GMI/BMI	Gorputz masa indizea/Body mass index.
GP	General population.
H	Altuera.
H_W Interaction	Height and weight interaction.
ICC	Inter-class correlation.
IP	Indize Ponderala.
ISAK	International Society of Advancement of Kinanthropometry.
MAJ/CMJ	Mugimenduaren aurkako jauzia/ Counter-movement jump.
MJ	Makurtutako jauzia.
Musc %	Muscle percentage.
N.S.	Non-significant
Yo-Yo IR1	Yo-Yo Etengabeko Suspertze Testa 1go Maila/ Yo-Yo Intermittent Recovery Test Level 1.
P	Zangoko perimetro zuzendua.
PHV	Altueraren puntako abiadura/Peak height velocity.
RAE	Adin erlatiboaren eragina / Relative age effect.
SkF	Total sum of skinfolds.

SCORE	Total score of performance (velocity test (15-m) + agility test (Barrow) + Yo-Yo IR1 + CMJ)
$SCORE^{HG}$	Total score of performance (velocity test (15-m) + agility test (Barrow) + Yo-Yo IR1 + CMJ + handgrip)
TEM	Neurketa errorea/ Technical error of measurement.
U	Ukondoko diametroa
VS.	Versus.
∑ Skinfolds	Total sum of skinfolds.
∑ Trunk skinfolds	Sum of trunk skinfolds.
∑ Extremities skinfolds	Sum of extremities skinfolds.

Aurkibidea

AURKIBIDEA

1. Sarrera

1. SARRERA

1.1. Futbola

Futbola munduko kirolik ezagunena da. Planeta osoan zehar milioika neska-mutilek jokatzen dute futbolean. Horietako askoren gelak beteta daude haien heroien posterrekin eta argazkiekin. Futbolari profesionala izatearekin amesten dute, eta, askok eta askok entrenatzen dute amets hori buruan dutelarik; hain zuzen ere, futbolean goi-mailan jokatzeko. Baina gutxi dira haien ametsa beteko dutenak. Izan ere, eliterako bidea luzea bezain gogorra da, eta gutxi batzuek bakarrik izango dute aukera talde txiki pribilegiatu horretan jokatzeko.

Gaur egun, taldeek gero eta garrantzi handiagoa ematen diote gazteen aukeraketari; horrela, ume ugari igarotzen dira urtero-urtero talde handien eskuetatik. Hala ere, bidean asko geldituko dira eta gutxi batzuek bakarrik lortuko dute haien helmuga. Baina, zein da bidean gelditu direnen eta aurrera jarraitzen dutenen arteko desberdintasuna? Argi dago bizitza luzea dela, eta, gainera, desberdinak direla gazte bakoitzak biziko dituen egoerak eta bere inguruan izango dituen baldintzak. Beraz, zaila da etorkizuneko “Messiak” begi hutsez antzematea. Hala ere, badira hainbat tresna gazteen arteko desberdintasunak nolakoak diren ezagutzen laguntzen digutenak; hain zuzen ere, horixe bera aipatu zuen Ekblom-ek 1999. urtean: “Futbolaren denboraren analisiek eta futbolarien ariketa fisikoaren azterketek neurri objektibo batzuk ematen dituzte; eta horrela, interpretazio objektiboa egin daiteke. Horrez gain, analisi hauek hobetu egiten dira ariketa fisikoaren datuekin batera azterketa fisiologikoak egiten direnean” (Ekblom, 1999).

Baina jokalari asko txiki-txikiak direnetik hasten dira futbolean jokatzen, hots, umetxoak direnetik. Kontuan hartzeko horrenbeste aldagai daude… Futbolean aritzen diren umetxo horiek guztiak nagusitu egingo dira: pertsona heldu bihurtuko dira. Eta heltze-prozesuan zehar hainbat eta hainbat aldaketa jasango dituzte; fisikoak zein psikologikoak... Izan ere, garai horretan gertatzen dira gure bizitzaren aldaketa esanguratsuenak. Bizitza horrelakoa baita: erlazionatzen gara, aldatzen gara, hazten gara, jolasten gara… azken finean, borobilean bizi gara, zikloka.

“Naturan denak dauka bere sortze-denbora: gutxika-gutxika egunak gaua dakar, eta gauak berriro argitzen du eguna; udak udazkena dakar, baina neguak udaberria zor du berriro ere… Dena aldaketa bortitzik gabe gertatzen da geldiezina den zikloari esker. Landareak hazi batetik hazten diren bezala gizakiak ere heldua bilakatzeko -eta, era berean futbolaria- garapen-fase desberdinetatik igarotzen da. Borobilean bizi gara. Dena programatuta dago ordena natural eta jarraitu batean; alabaina, naturaren programazioan ez dago desorekarako lekurik” (Wein, 2004).

1.2. Jokoa

Futbola kirol konplexua da. Garaipena, joko aldeaniztun honetan, aldagai fisiologiko, tekniko eta taktikoen menpe dago (Stølen, Chamari, Castagna, & Wisløff, 2005). Hori dela eta, goi mailan lehiatzeko beharrezkoak dira aldagai biologiko zein portaera-ezaugarri batzuk: tamaina, gaitasun fisikoak eta gorputz-osaketa; abiadura, bizkortasuna eta potentzia; futbolarien gaitasun espezifikoak, hala nola baloiaren kontrola, pasea eta jaurtiketa; gaitasun somatiko-pertzeptiboak, adibidez, aurre hartzea eta jokoan zehar beste jokalariak bilatzea; trebetasun psikologikoak: motibazioa, kooperazioa, imitazioa eta arreta, besteak beste. Gainera, garrantzitsua izango da jokoaren zentzua, hots, joko-inteligentzia (Williams & Reilly, 2000). Dena den, hainbat lanetan ikusi den bezala, aipagarria da maila altuko futbolariek ez dutela zertan erakutsi edozein arlotan itzelezko ahalmena, nahiz eta ahalmen jakinetan gutxienezko maila bat erakustea beharrezkoa duten (Hoff & Helgerud, 2004).

Partidak iraungo duen denboran zehar mugimendu azkar eta indartsuak egin ahal izateko gaitasun aerobiko eta anaerobiko ona izan behar du futbolariak (Bangsbo, Mohr, & Krustrup, 2006). Berez, etenak dituen jarduera bezala definitua izan da kirol hau, hots, akzio ugari eta interakzio ez lineal anitzez betetako jokoa; beraz, ulertzekoa da bi metabolismoak behar izatea. Horrela, partida batean intentsitate baxuko aldi egonkorrak intentsitate altuko aldi laburragoekin tartekatzen dira (Bansgbo, Nørregaard, & Thorsø, 1991).

Reilly-rentzat eta Thomas-entzat (1977) jokalari bakoitzak partidan zehar egiten duen distantzia da zehazten duena; alde batetik, ariketaren bataz besteko intentsitatea, eta, bestetik, taldearen ahalegin orokorrari bakoitzak egiten dion ekarpena. Honekin lotuta, aipatu behar dugu bibliografian aurkitu ditugun distantziak oso desberdinak direla, batez ere neurketak egiteko erabili diren metodologiak desberdinak izan direlako. Adibidez, 1976. urtean Reilly eta Thomasek ondorioztatu zuten jokalariek 8.680 m korrika egiten zituztela; aldiz, Ekblom-ek (1986) distantzia hori 9.800 m-koa zela aurkitu zuen. Azken urteotan distantziak neurtzeko ordenagailu-analisiak erabili dira, eta, horrela ere, emaitzak desberdinak izan dira: 10.549 m, alegia (Zubillaga, Gorospe, Hernández Mendo, & Blanco Villaseñor, 2007). Honetaz guztiaz gain, ikusi da aldagarritasuna dagoela distantzia maximoan bai ligaren arabera (Drust, Reilly, & Rienzi, 1998; Rienzi, Drust, Reilly, Carter, & Martin, 2000), bai talde baten partiden artean (0.9-1.7 km-ko aldea) (Bangsbo eta lank., 1991; Bangsbo & Michalsik, 2002), eta baita partidako bi zatietan ere, non bigarren zatian distantzia txikiagoa betetzen den: % 5-9 inguru (Bangsbo & Michalsik, 2002; Shephard, 1999; Tumilty, 1993b).

1.3. Jokalariak

1.3.1. Antropometria

Antropometriari dagokionez, eliteko futbolari helduak maila baxuagokoak baino zaharragoak, altuagoak eta astunagoak izaten dira (Casajús & Aragonés, 1997). Antzerako emaitzak topatu dira adin txikiko jokalarietan (Gil, Gil, Ruiz, Irazusta & Irazusta, 2007), nahiz eta kasu guztietan berdin gertatzen ez den (Cometti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001; Wisløff, Helgerud, & Hoff, 1998). Tamaina handiak (altuera eta pisua) errendimendu-aldagai gehienekin erlazio positiboa du, adibidez, ahalmen- aerobikoarekin eta indarrarekin (Shephard, 1999; Malina, Eisennman, Cumming, Ribeiro, & Aroso, 2004), jauzi-garaierarekin, baloiaren jaurtitze-abiadurarekin eta 10 m eta 30 m-ko lasterketako denborekin ere (Wong, Chamari, Dellal, & Wisløff, 2009).

Somatotipoak gorputza deskribatzen du bere hiru osagaien bidez: endomorfia, mesomorfia eta ektomorfia (Heath & Carter, 1967). Lehen osagaia edo endomorfia gantz-kantitatearekin edo loditasunerako joerarekin erlazionatuta dago. Bigarren osagaia edo mesomorfia muskuluaren adierazlea da. Hirugarren osagaiak edo ektomorfiak linealtasuna adierazten du, hau da, luzera-neurriak zeharkakoak baino handiagoak direla. Hiru osagaiak beti ematen dira zenbakiz eta ordena horretan. Horrela, eliteko futbol-jokalarien ohiko somatotipoa hurrengoa dela esan dezakegu: 3-5-2.5 (Rienzi eta lank., 2000; White, Emery, Kane, Groves, & Risman, 1988).

Orokorrean, kirolariek mesomorfiarekin erlazio handiagoa izaten dute; futbolean ere berdina gertatzen da (Reilly, Bangsbo, & Franks, 2000). Ondorioz, ulertzekoa da futbolarien gorputzaren gihar-portzentajea sedentarioena baino altuagoa izatea; berez, % 62-ra ere hel daiteke (Rienzi eta lank., 2000; Reilly eta lank., 2000). Gainera, gihar-edukierak errendimenduarekin erlazio positiboa du (Baldari eta lank., 2009; Hansen, Bangsbo, Twisk, & Klausen, 1999; Rienzi eta lank., 2000).

Gantz-portzentajea, berriz, pertsona sedentarioena baino baxuagoa bada ere, distantzia luzeko kirolariena baino altuagoa da (Shephard, 1999). Gantz-edukiak eta honek eragiten duen gain-pisuak erlazio negatiboa du errendimenduarekin, gantzak mugimenduak zailtzen baititu (Reilly eta lank., 2000; Baldari eta lank., 2009).

Jokalari gazteei dagokienez, 14-15 urtetik beherakoak ektomorfia handiagoa dutela ikusi da (Gil, Gil, eta lank., 2007; Vaeyens eta lank., 2006). Nahiz eta hazten doazen heinean mesomorfia handitu egiten den, gaztaroan mesomorfia-baloreak ez dira eliteko futbolarien mailetara heltzen (Gil, 2003). Eran berean, aipagarria da 14 urteko maila ertaineko futbolariak, hautaketa-prozesu zorrotzetan aukeratuak izan direnak, ez-hautatuak baino handiagoak direla eta gantz-eduki txikiagoa eta gihar-eduki handiagoa erakusten dutela (Reilly, Williams, Nevill, & Franks, 2000; Rico-Sanz, 1998). Hori dela eta, zenbait lanetan aipatzen da futbolariek tamaina handiagoa dutela hautaketa-prozesuen eraginagatik (Baxter-Jones, Goldstein, & Helms, 1993; Gil, Gil, eta lank., 2007).

1.3.2. Aldagai fisiologikoak eta errendimendua

Aurretik aipatu dugu futbolean intentsitate baxuko ariketak egiten direla batez ere. Beraz, jokalariek partidaren zatirik handiena oinez, footing egiten edo intentsitate baxuan korrika egingo dute. Berriz, intentsitate altuetan (metabolismo anaerobikoan) momentu laburragoetan jolastuko dira, alegia, % 8-13 inguru (Tumilty, 1993b). Hala ere, momentu hauek erabakigarrienak izan ohi dira. Horregatik, hainbat autorek pentsatzen dute ahalmen anaerobikoak hobeto definitzen duela jokalarien maila (Tumilty, 1993b; Hoff & Helgerud, 2004). Egiaz, jokaldi horietatik etor daiteke arerioari baloia kentzeko aukera, baloi “galdu” bat irabaztea, gol bat sartzea... Laburbilduz, azken batean, partida irabaztea (Le Gall, Carling, Williams, & Reilly, 2010; Gil, Gil, Ruiz, Irazusta, & Irazusta, 2010; Reilly eta lank., 2000). Futbolarien metabolismo aerobiko eta anaerobikoa, eta errendimendua hurrengo ataletan aztertzen diren testen bitartez neurtzen dira.

Abiadura

Abiadura ezinbesteko parametroa da futbolean (Gil, 2003). Autore askok abiadurak ahalmen handia duela deritzote futbol-maila ezberdinetako taldeak bereizteko, eta ezaugarri bereizle bezala definitu izan dute (Reilly eta lank., 2000; Stølen eta lank., 2005). Normalean, futbol partida batean laburrak izaten dira esfortzu maximoan egindako distantziak, hots, abiadura handian egindako esprintak. Orobat, esprinten %96-a 30-m baino gutxiagoko distantzian egiten dira (Mohr, Krustrup, & Bangsbo, 2003). Hau horrela izanda, jokalarientzat garrantzitsua da intentsitate altuko denbora labur horietatik ahalik eta lasterren berreskuratzea (Bangsbo, 1994).

Abiadura neurtzen duten probak egitean maila altuagoko futbolari helduek abiadura handiagoa dutela ikusi da (Tumilty, 1993b; Shephard, 1999). Gainera, elite mailako futbolariak azkarragoak dira ez-profesionalak baino (Bangsbo eta lank., 1991; Cometti eta lank., 2001). Era berean, adin gazteko jokalariekin ere antzerako emaitzak lortu izan dira: adibidez, azpimarratu izan da 11 eta 12 urteko futbolarientzat abiadura garrantzizkoa dela (Castagna eta lank., 2006). Hau gutxi balitz, abiadura-proba desberdinetan alde nabariak daude maila altu eta baxuagoen artean futbolari gazteetan (12-16 urte) (Vaeyens eta lank., 2006); eta, elitekoak sub-elitekoak baino bizkorragoak dira (Figuereido, Gonçalves, Coelho E Silva, & Malina, 2009).

Trebetasuna

Nahiz eta futbol partidetan energia aerobikoaren eskakizuna handia izan, orokorrean, mugimendu espezifikoak distantzia labur, errepikakor eta intentsuetan burutzen dira. Hain zuzen ere, mugimendu hauek guztiak oinarritzen dira jauzietan, esprintetan eta norabide aldaketetan (Wragg, Maxwell, & Doust, 2000). Horrela, trebetasun probetan neurtzen da distantzia laburretan jokalariek mugimendu konplexuak arintasunarekin edo bizkortasunarekin egiteko duten gaitasuna (Sheppard & Young, 2006).

Zenbait autoreek trebetasuna errendimenduaren adierazle garrantzitsu moduan definitu izan dute. Honenbestez, ikusi egin da jokalari helduetan eliteko jokalariak sub-elitekoak baino azkarragoak direla trebetasun probetan (Reilly eta lank., 2000; Svensson & Drust, 2005) eta baita 12-16 urte bitarteko jokalari gazteetan ere (Vaeyens eta lank., 2006). Era berean, futbolean jolasten jarraitzen duten jokalari gazteak jolasteari usten diotenak baino trebeagoak dira (Figueiredo eta lank., 2009; Gil, Ruiz, eta lank., 2007).

Indar esplosiboa: jauziak

Futbolean indar esplosiboa beharrezkoa da akzio asko burutu ahal izateko; adibidez, baloia kolpatzeko, norabide aldaketa egiteko edo jauziak burutzeko. Akzioak burutzeko behar den indarra erlazionatuta dago mugimenduak burutzeko giharrek behar duten indarrarekin. Horrela, autore batzuek ikusi dute da futbol jokalariek populazio orokorrak baino gihar indar handiagoa dutela (Bangsbo, 1994; Reilly eta lank., 2000; Wisløff eta lank., 1998).

Futbolarien behealdeko gorputz-adarretako indar esplosiboa neurtzeko jauzien testak erabiltzen dira (Gil, 2003). Ikerlan gehienetan hiru jauzi mota erabiltzen dira: makurtutako jauzia (MJ), mugimenduaren aurkako jauzia (MAJ) eta erorketa jauzia (EJ) Ingelesez jauzi hauek guztiak hurrenez hurren "*squat jump*", "*counter-movement jump*" eta "*drop jump*" izenez ezagutzen dira. Hiru jauziek neurtzen dute indar esplosiboa, baina beste zerbait ere neurtzen dute: MAJ jauziak, giharren osagai erreaktiboa; eta EJ jauziak, osagai elastiko erreaktiboa (Bosco, 1994; Rico-Sanz, 1997). Aipagarria da, beste kirolari batzuekin alderatuta futbolariek bitarteko jauzi-ahalmena dutela (Kirkendall & Street, 1986). Adibidez, futbol jokalari batek altuera jauzian lehiatzen den atletak baino jauzi txikiagoa burutuko du baina, aldiz, igerilari batek baino jauzi garaiagoak. Izan ere, futbolarien gihar- eta nerbio-egitura futbol-jokoari hoberen doitutako mugimenduetara moldatuta daude eta ez zehazki jauzi egiteko ahalmenera (Eloranta, 2003). Hala ere, futbolarien jauzi-ahalmen handiak positiboki eragiten du bere errendimenduan (Hansen eta lank., 1999).

Horrela, Arnason eta lankideek erlazioa aurkitu zuten jauzi-garaieraren eta ligan azaldutako errendimenduaren artean (Arnason eta lank., 2004). Hala ere, zaila da konparaketa egitea ikerketek jauzi-mota desberdinak erabili baitituzte, hots, metodologia desberdina erabiltzen dute. Horregatik, aipagarria da lan batzuetan jokalari gazteek nagusiagoek baino jauzi txikiagoa egiten zutela ikusi den arren (Gil, 2003), eta maila arteko desberdintasunak daudela aurkitu duten ikerketak dauden arren (Figueiredo eta lank., 2009), zenbait autorek mailen arteko desberdintasunik ez dagoela aurkitu dutela (Stølen eta lank., 2005; Williams & Reilly, 2000) ez eta adin guztietan ere (Vaeyens eta lank., 2006).

Erresistentzia

Lehen aipatu dugun moduan, jokalariek partidaren zatirik handiena oinez, footing egiten edo intentsitate baxuan korrika egingo dute; baina, aldi berean, intentsitate altuetan jolastuko dira jokoaren momentu zehatzetan (Tumilty, 1993a). Beraz, jokalariek intermitenteak izango diren eta intentsitate desberdinak izango dituzten akzioak mantendu beharko dituzte denboran zehar. Hori dela eta, futbol-jokalarien indar- eta egokitzapen-programek lehentasunez kontuan hartzen dute intentsitate altuko jarduera aerobikoa atalase anaerobikotik hurbil mantentzeko ahalmena (Miller eta lank., 2007). Hortaz, entrenamendu aerobikoak jokalarien gaitasuna handitzen du partidan zehar intentsitate altuago batean aritzeko eta, era berean, txikitzen du nekearen ondorioz teknikaren errendimenduan ematen den jaitsiera (Bangsbo & Krustrup, 2009). Urte batzuk badira akzio intermitente hauek neurtzeko Yo-Yo IR1 (Bangsbo, Iaia, & Krustrup, 2008) erabiltzen dela.

Proba hau intentsitate altuko lan aerobikoa errepikaturik burutzeko gaitasunean dago oinarriturik. Horrela, probak bide aerobikoaren eta anaerobikoaren partaidetza altua eskatzen du eta aukera ematen du ariketa fisiko trinkoa burutzean pertsonek duten errekuperatzeko ahalmena aztertzeko (Krustrup eta lank., 2003).

Bangsbo eta kolaboratzaileek (2008) maila desberdinetako futbol-jokalariekin Yo-Yo IR1 proba erabili zuten eta ikusi zuten eliteko jokalariak 2.420 m egiteko gai zirela; berriz, sub-eliteko jokalariek 2.030 m egin zituzten. Honek eliteko jokalarien erresistentzia-gaitasuna handiagoa zela egiaztatu zuen. Era berean, adin-taldeak konparatzean antzerako emaitzak lortu ziren: jokalari gazteek jokalari nagusiek baino metro gutxiago egin zituzten; zehazki, 16 eta 17 urte bitarteko jokalariek seniorrek baino % 30 m gutxiago (Bangsbo eta lank., 2008).

1.4. Garapenean dauden jokalariak

Orain arte ikusi dugun moduan, ikerketa ugari burutu dira futbolean eragina duten aldagaiak jakiteko zeintzuk diren. Ikerketa gehienak jokalari helduekin burutu dira baina jokalari gazteekin egindako ikerketak geroz eta garrantzitsuagoak bihurtzen ari dira. Izan ere, maila altuko klubentzat, haien finantziazio-estatusa mantentzearren lehentasun bihurtu da jokalari gazteen hautatze-prozesua, garapena eta profesionaltasuna (Vaeyens eta lank., 2006). Bestetik, ez da batere erraza gazteak eliteko jokalari bihurtuko direla ziurtatzen duen prozesua garatzea eta uztartzea, zaila suertatzen baita jokalarien ebaluazioa (Malina, Bouchard, & Bar-Or, 2004; Philippaerts eta lank., 2006). Hain zuzen ere, haurtzaro eta nerabezaroan dauden aldaketa fisiko eta hormonal handiek (Hansen eta lank., 1999) emaitza ezberdinak sortzen dituzte errendimenduan, eta, honek aldagaien ebaluazioa zaildu egiten du (Hansen eta lank., 1999; Vaeyens eta lank., 2006).

1.4.1. Hazkuntza eta heltzea

Hazkundea eta heltzea aldaketa somatikoz betetako prozesu dinamikoak dira (Rogol, Roemmich, & Clark, 2002). Prozesuak diren heinean, ikusi egin da altuerak eta pisuak lau aro jarraitzen dituztela: hazkunde arina lehen haurtzaroan, hazkunde geldoagoa haurtzaroaren erdialdean, hazkunde arina nerabezaroaren hasieran, eta hazkunde geldoa heldutasuneraino (Malina, Bouchard, & Bar-Or, 2004).

Hazkunde prozesuan gorputz-proportzioetan eta gorputz-osaketan gertatzen diren aldaketak berezkoak dira (Rogol eta lank., 2002). Nahiz eta lau aroetan zehar hazkuntza-pikoak gertatzen diren, hazkunde-pikorik handiena nerabezaroaren hasieran gertatzen da; piko honi *altueraren puntako abiadura* (*peak height velocity*) deritzo. Era berean, puntako abiadura hau gertatzen den adinari a*ltueraren puntako abiaduraren adina* (*age at peak height velocity, APHV*) deitzen zaio; mutiletan 14.5 urte inguruan ematen da, eta, aldiz, nesketan 12.5 urte inguruan (Willmore & Costill, 1998). Oro har, altuera eta pisua bezala, gorputzaren beste neurriak ia eredu berarekin hazten dira; bai perimetroak eta bai diametroak, baita gihar-edukia edota gantzik gabeko masa (GGM) ere (Malina, Bouchard, & Bar-Or, 2004; Rogol, 2002; Rogol eta lank., 2002). Ordea, gantz-edukian mutiletan, batez ere gorputz-adarretan, txikipena gertatzen den bitartean, nesketan gantz-kopurua handitu egiten da (Malina, Bouchard, & Bar-Or, 2004; Rogol, 2002).

Hazkundearen eta heltzearen prozesuak hormonen eraginez gertatzen dira; besteak beste, testosterona bezalako hormona androgenikoei, hazkunde-hormonari, hormona tiroideoari, intsulinari eta abarrei esker (Rogol, 2002; Rogol eta lank., 2002). Hein handi batean, pisua, indarra eta altuera irabaztea nerabezaroan ematen diren aldaketa hormonal eta fisiologiko hauekin lotuta daude (Hansen eta lank., 1999). Horregatik, zeregin konplexua izaten da tamaina eta errendimendu nagusitasuna heltze biologikoa eman delako, edo, berez, jokalaria etorkizunean hobeagoa izango delako zehaztea (Malina eta lank., 2005). Ondorioz, adin biologikoa kontrolatzea garrantzitsua da (Baxter-Jones, Eisenmann, & Sherar, 2005; Beunen eta lank., 1992; Peña-Reyes, Cardenas-Barahona, & Malina, 1994).

Adin biologikoa vs. Adin kronologikoa

Adin biologikoak gizakien heltze-maila neurtzen du. *Adin kronologikoak,* berriz, gizaki batek jaiotzatik hasita dituen egunak, hileak edo urteak neurtzen ditu. Adin biologikoa eta kronologikoa batera joan daitezkeen arren, ez dira sinonimoak (Gil, 2003). Adin-kronologiko berdineko jokalariek adin biologiko desberdina izan dezakete, eta, beraz, haien garapen- eta hazkunde-maila desberdina izango da.

Horrela, gazteak heltze-mailaren arabera sailkatzen dira: *heltze ertaina* (ingelesez *average maturity*) duten gazteak, hau da, adin kronologikoa eta adin biologiko parekoa dutenak; *heltze goiztiarra* (ingelesez *early maturity*) adin kronologikoa baino adin biologiko goiztiarragoa dutenak, orokorrean, gutxienez urte bat goizago; eta heltze berantiarra (ingelesez *late maturity*) batez bestez gutxienez urte bat beranduago dutenak (Malina, Bouchard, & Bar-Or, 2004). Hiru talde hauetako gazteek era berdinean haziko dira, baina erritmo desberdinean; hau da, garapena berdina izango da baina goizago edo beranduago gertatuko da (Zubero eta lank., 2007).

Zenbait autorek adin biologikoa kontrolatzea garrantzitsua dela aipatu dute (Beunen eta lank., 1992; Peña-Reyes eta lank., 1994). Adin biologikoa neurtzeko zenbait adierazle erabiltzen da. Nahiz eta bakoitzak neurtzeko modu desberdina izan, batez ere hiru modutan neurtu daiteke adin biologikoa (Malina & Bouchard, 1991): 1) hezur-adina kalkulatu eskumuturreko erradiografiak aztertuz (Tanner Whitehouse metodoarekin) (Beunen, Ostyn, Simons, Renson, & Van Gerven, 1981; Bouchard, Malina, Hollmann, & Leblanc, 1976), 2) heltze sexuala neurtzeko teknika desberdinak erabiliz, besteak beste: a) gazteen bigarren mailako sexu-karaktereak deskribatuz (Tanner-en estadioak) (Malina, Bouchard, & Bar-Or, 2004; Malina, Chamorro, Serratosa, & Morate, 2007; Gilsanz & Ratib, 2005; Tanner, 1962), b) odoleko hormona androgenikoen kontzentrazioa neurtuz (Hansen eta lank., 1999) edo c) listuko testosterona eta dehidroepiandrosterona (DHEA) mailak neurtuz (Granger, Schwartz, Booth, Curran, & Zakaria, 1999; Granger, Schwartz, Booth, & Arentz, 1999), eta 3) altueraren puntako abiaduraren adinaren arabera.

Altueraren puntako abiadura ekuazio baten bitartez estimatzen da eta, horretarako, atzera begirako datuak beharrezkoak dira. Hori dela eta, altueraren puntako abiaduraren adina estimatzeko, ikerketa longitudinalak beharrezkoak dira (Malina, 1994).

Hazkunde hormonak

Hainbat ikerketek erakutsi dute metodo baliagarria dela heltze-maila zehazteko listuan aurkitzen den testosterona kontzentrazioa neurtzea; berez, korrelazionatu egiten dira plasman eta listuan aurkitzen diren kontzentrazio mailak (Dabss, 1990a, 1990b); Granger eta lank., 2007; Ostatníková eta lank., 2002; Rilling, Worthman, Campbell, Stallings, & Mbizva, 1996). Gainera, Rilling eta lankideek (1996) antzeko emaitzak lortu zituzten gazteen bigarren mailako sexu-karaktereak (Tanner-en estadiajea) eta listuko testosterona mailak neurtzean, eta, beraz, hauek ere ondorioztatu zuten listu-lagin bilketa heldutasuna neurtzeko metodo baliagarria dela.

Hari beretik jarraituz, listua hurrengo osagaiez osatua dago: hormonak, peptidoak, elektrolitoak, mukiak, konposatu antibakterioak eta zenbait entzima (Papacosta & Nassis, 2011). Listuan aurkitu daitezkeen hormona esteroideen kontzentrazioa (kortisola, testosterona, DHEA, estrogenoa, progesterona eta aldosterona) beste fluido batzuetan aurkitzen dena baino askoz ere txikiagoa da (Granger, Shirtcliff, Booth, Kivlighan, & Schwartz, 2004; Ostatníková eta lank., 2002; Papacosta & Nassis, 2011; Rilling eta lank., 1996). Hala ere, metodo honek hainbat abantaila ditu fluidoak hartzeko beste metodo batzuekin konparatzen baldin badugu (adibidez, gernu, serum edo plasma neurketekin) (Granger, Schwartz, Booth, & Arentz, 1999). Alde batetik, aplikatzeko metodo azkarragoa eta errazagoa da lagin asko hartu behar direnean, adibidez, epe luzeko ikerketetan. Beste alde batetik, behar bereziak dituzten pertsonentzat egokiagoa da, zailtasunak egon daitezkeelako proba inbasiboak egiteko eta, horren ondorioz, baimenak lortzeko.

Gainera, listu-lagin bilketa prozedura ez inbasiboa denez, adin txikiko jokalariekin aplikatzeko aproposagoa da (Granger, Schwartz, Booth, Curran, & Zakaria, 1999). Gainera, eta kirol arloari dagokionez, bilketa burutzeko ez da jakintza medikurik behar eta kirol-zelaian bertan edota aldageletan burutu daiteke (Papacosta & Nassis 2011).

Goian aipatu dugun moduan, haurtzaro eta nerabezaroan dauden aldaketa fisiko eta hormonal handiek (Hansen eta lank., 1999) emaitza desberdinak sortzen dituzte errendimenduan, eta, horrela, aldagaien ebaluazioa zaildu egiten du (Hansen eta lank., 1999; Vaeyens eta lank., 2006). Aldaketa fisiko horietan guztietan eragin gehien duten hormonetariko bi testosterona eta DHEA dira.

Testosterona, hormona androgenoa da; organo sexualek (testikuluek eta obarioek) ez ezik, guruin endokrinoak ere jariatzen du hormona hau. Emakumezkoetan, plasman aurkitzen diren testosterona-baloreak gizonezkoetan baino 10-20 aldiz txikiagoak dira. Gizonetan, testosteronak espermatogenesia (espermaren produkzioa, alegia) eta organo genitalen garapena kontrolatzen ditu. Horretaz gain, gaztaroan bigarren mailako karaktere sexualak agertarazten ditu (ilea, ahots-aldaketak eta gihar-masaren handitzea). Halaber, metabolismoan ere eragina nabarmena du; esaterako, proteinen sintesia eta gantzen katabolismoa areagotzen du (Havelock, Auchus, & Rainey, 2004; Netherton, Goodyer, Tamplin, & Herbert, 2004).

DHEA, giltzurrun-gaineko guruinek jariatzen duten hormona endogenoa da. Nahiz eta esteroide ahul moduan sailkatzen den, indartsuagoak diren beste hormona batzuen aitzindari da (Kroboth, Salek, Pittenger, Fabian, & Frye, 1999; Netherton eta lank., 2004). Edozelan ere, hormona honen eragin androgenikoa oso txikia da; hots, bere garrantzia testosteronaren aitzindari izatean datza (Havelock eta lank., 2004).

Orokorrean, giltzurrun gaineko guruina DHEA-ren zirkulazio eragilea bada ere, gizonezko eta emakumezkoen artean desberdintasunak aurkitu ditzakegu. Alde batetik, gizonezkoek emakumezkoek baino DHEA gehiago dute (Kroboth eta lank., 1999; Netherton eta lank., 2004; Weise, Eisenhofer, & Merke, 2002). Alabaina, gizonezkoetan giltzurrun gaineko guruinetan jariatzen den kopurua oso txikia da; bada, % 10 eta % 25 artean testikuluetan jariatzen da. Aldiz, emakumezkoetan, giltzurrun gaineko androgenoek kopuru orokorraren % 50 osatzen dute (Kroboth eta lank., 1999).

Honetaz gain, aipatzekoa da adina eta sexuaren arabera DHEA kontzentrazioa aldakorra dela (Corrigan, 1999; Havelock eta lank., 2004; Papacosta & Nassis, 2011). Jaio eta lehen hilabetetik bosgarren urtera, kontzentrazioa asko txikitzen da. Ondoren, 9 urtetik aurrera, kontzentrazioa azkar handitzen da: pertsonaren arabera 20 eta 30 urte bitartean heltzen da bere puntu gorenera. Bukatzeko, 70 eta 80 urte artean kontzentrazioak asko txikitzen dira berriro: zehatz-mehatz, % 20 gizonezkoetan (Kroboth eta lank., 1999).

Laburbilduz, frogatu da bi hormona hauek metodo onak direla heltze biologikoa zehazteko eta honek errendimenduan duen eragina neurtzeko.

Altueraren puntako abiadura

Azken urte hauetan ikerketa askok *altueraren puntako abiadura* (APHV) erabili dute kirolari gazteen heldutasun maila neurtzeko (Malina eta lank., 2011; Matthys, Vaeyens, Coelho-E-Silva, Lenoir, & Philippaerts, 2012; Sherar, Baxter-Jones, Faulkner, & Russell, 2007; Till, Cobley, O'Hara, Chapman, & Cooke, 2010; Vandendriessche eta lank., 2012). Metodo honen bitartez umeak aurretik aipaturiko hiru heldutasun-mailatan desberdindu daitezke. Orokorrean, *altueraren puntako abiadura* nesketan 12.5 urterekin gertatzen da eta mutiletan, aldiz, 14.5 urterekin. Hortaz, 11.5 eta 13.5 urte dituzten neska-mutilak, hurrenez hurren, *heltze goiztiarra* izango dute eta 13.5 eta 15.5 urte dituztenak, berriz, *heltze berantiarra*.

APHV-a ekuazio baten bitartez balioztatzen da (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Ekuazioak aurresaten du jokalariaren puntako abiaduraren adina zein izango den (adin horri ingelesez *maturity offset* deritzo) eta aurresandako adin horren eta jokalariaren adin kronologikoaren artean zenbat urteko desberdintasuna dagoen. Ekuazioaren aplikazioa gomendatuta dago abiadura punta orokorretik -4 eta +4 urte bitartean dauden jokalarientzat.

1.4.2. Hazkuntza, heltzea eta errendimendua

Hazkuntzak gorputz-osaketan, proportzioetan eta dimentsioetan ez ezik, errendimenduan ere eragina dauka (Helsen, Hodges, Van Winckel, & Starkes, 2000). Horrela, nahiz eta altuera, pisua eta adina nerabezaroan ematen diren aldaketen zati baten eragileak diren, eraginik handiena heltze biologikoarena da (Baxter-Jones eta lank., 2005; Rogol, Clark, & Roemmich, 2000). Gertatzen diren aldaketa hauek guztiak handiak dira, bai ezaugarri fisikoetan (Geithner, Satake, Woynarowska, & Malina, 1999; Rogol eta lank., 2002), baita ezaugarri fisiologikoetan ere (Malina, Bouchard, & Bar-Or, 2004; Rowland, 2005). Gainera, kontuan hartzekoa da kirolean arrakasta duten kirolarien hazkuntza-maila populazio orokorrarekiko desberdina dela (Beunen eta lank., 1992; Gil, 2003). Horregatik, garrantzitsua da errendimendua eta hazkuntza-mailaren arteko erlazioa nolakoa den aztertzea (Beunen & Malina, 2007). Hala ere, kontuan hartu behar da, hainbat heldutasun-markatzaile ia errendimendu ezaugarri denekin erlazionatzen diren arren, hainbat eragilek ere eragina badutela errendimenduan; besteak beste, gorputz-osaketa, somatotipoa, ingurumen soziala, eta, futbolaren kasuan, futbol-praktika.

Hazkundea errendimendu-parametro desberdinekin erlazionatzen dela ikusi dugu baina, hala ere, zaila gertatzen da erlazio hau nolakoa den zehaztea. Izan ere, erlazioa aldagarria da aztertzen den ezaugarrien arabera eta baita aztertzen den adinaren arabera (Malina, Bouchard, & Bar-Or, 2004). Nolanahi ere, jarraian ikusiko dugun moduan, orokorrean, heldutasunera heltzean hobekuntzak ikusten dira ezaugarri gehienetan.

Adibidez, indar estatikoa umezarotik nerabezaroko trantsizioan linealki handitzen dela ikusi da (Hansen eta lank. 1999). Hein handi batean errendimendu-hobekuntza hau gihar-masaren hazkundearekin batera gertatzen da (Wilmore & Costill, 1998). Mutilen kasuan, 13 urte inguruan nabaria da indarraren azelerazioa (Beunen & Malina, 2007). Gainera, indar esplosiboan ere hobekuntzak nabariak dira umezarotik heldutasuneraino. Indar hau neurtzeko, jauziak erabiltzen dira; horrela, populazio orokorrarekin egindako ikerketetan ikusi egin da jauzi bertikalaren balioak adinarekin hobetzen doazela (Malina & Bouchard, 1991). Era berean, futbol jokalariekin lortutako emaitzak antzekoak izan dira: Le Gall eta lankideek (2010) ondorioztatu zuten jauzi handiagoak egiten zituztela handiagoak ziren jokalariek.

Ezaugarri gehiagorekin jarraitzeko, trebetasuna horrela definitua izan da: abiadura handian oztopo desberdinak ekiditeko, iskin egiteko mugimenduak edo norabide aldaketak egiteko gaitasuna (Vaeyens eta lank., 2006). Hazkunde-prozesuan, umeak heldutasunera hurbiltzen diren heinean, oreka-, bizkortasun- eta koordinazio-hobekuntza izaten dute, eta, hori dela eta, trebetasunaren emaitzetan ere hobetu egiten dute. Koordinazioaren hobekuntza nerbio-sistemaren garapenarekin batera ematen da. Alabaina, aski ezaguna da 6 eta 8 urte bitartean egitura neural gehienek eta mugimendu eredu gehienek heldu-forma hartzen dutela (Wilmore & Costill, 1998). Ildo honi eutsiz, trebetasuna neurtzeko lasterketa arinetan hobekuntza handiak ikusi dira 5-8 urte bitarteko jokalarien artean; adin horren ostean hobekuntzak ematen dira baina asko ere astiroago gertatzen dira; hots, ez da azelerazio handirik nabarmentzen (Wilmore & Costill, 1998). Abiaduran ere hobekuntzak nabariak dira mutiletan 8 urte inguruan, eta baita beranduago ere, alegia, 12 eta 15 urte bitartean. Parametro honetan eragina izango dute bai koordinazioak eta baita gihar-masaren handitzeak ere. Hainbat ikerketak baieztatu dute, adibidez Vaeyens eta lankideek (2006) egindakoan, abiadura eta trebetasuna adinarekin eta heldutasun mailarekin hobetzen direla.

Aurrean aipatu dugun bezala, zaila suertatzen da zehaztea zergatik gertatzen den futbolarien gaitasun espezifikoen hobekuntza: praktikaren eraginagatik edota berezko aurrerapenen eraginagatik (Malina, Bouchard, & Bar-Or, 2004). Ikusi da futbolean erlazionatuta dagoela oinarrizko gaitasun motorren garapena umearen eguneroko aktibitatearen eta futbol-praktikaren hasiera goiztiarrarekin. Hori dela eta, adin txikitan gaitasun jakinak praktikatzeak garrantzia du. Oro har, mutil futbolariek 11 urterekin futbol-mugimenduen eredua bereganatzen dutela ikusi da (Reilly, Williams, Nevill, & Franks, 2000).

1.5. Hautaketa prozesuak

2.5.1. Tamaina eta heltze biologikoa

Jakin badakigu gazte kirolarietan heldutasun goiztiarra maila altuan egotearekin erlazionatzen dela (Morris, 2000; Stratton, Reilly, Williams, & Richardson, 2004; Zubero eta lank., 2007). Hain zuzen ere, heldutasun aurreratua izatea tamaina handiagoarekin, potentzia handiagoarekin eta indar handiagoarekin erlazionatzen da, hots, errendimendu hobeagoa izateko beharrezkoak diren ezaugarriekin. Aurretik ere aipatu dugu nerabezaroan nabarmena dela ezaugarri horien guztien hobetzea, eta, nahiz eta hainbat parametrok eragina duten, eraginik handiena heltze biologikoarena dela (Rogol eta lank., 2000).

Heltze biologikoarekin lotuta, orain dela urte batzuk uste zen kirolak heltze-mailan eragina zuela. Aldiz, gaur egun, hipotesi hau aldatu egin da. Orohar, onartzen da aukeraketa dela tamaina handiagoko jokalariak egotearen arrazoia. Hori, heltze-maila aurreratuagoko jokalariak daudelako gertatzen da (Juricskay & Mezey, 1994; Peña-Reyes eta lank., 1994; Nevill, Holder, & Watts, 2009). Gainera, gazte hauek tamaina handiagoa izateaz gain proba fisikoetan ere emaitza hobeagoak izaten dituzte (Beunen eta lank., 1997; Jones, Hitchen, & Stratton, 2000; Malina & Bouchard, 1991). Beraz, badirudi jokalariak tamainaz handiak izatea aurretik buruturiko selekzio prozesu baten menpe egon daitekeela (Gil, Gil, eta lank., 2007).

Laburbilduz, jokalariak haien heltze-mailagatik abantailadunak edo abantaila gabeak izan daitezke termino eta aldagai fisikoetan; horregatik ez da harritzekoa, entrenatzaile eta monitoreek jokalari abantailatsuak aukeratzeko joera izatea, alegia, heltze biologiko handiagoa dutenak. Oro har, jokalari hauen emaitzak, batez ere proba fisikoetan, heltze berantiarrekoak baino hobeagoak izaten dira (Carling, Le Gall, Reilly, & Williams, 2009).

Tamaina eta heltzearekin lotuta, adibidez, hain zuzen ere 13-15 urte bitarteko jokalariekin egindako ikerketan, Malina, Bouchard eta Bar-Or (2004) ikusi zuten Tanner-en lehenengo heltze-estadioan zeuden jokalariak azkeneko estadioan zeudenak baino baxuagoak (20.1 cm gutxiago) eta arinagoak (2.4 kg gutxiago) zirela. Beste ikerketa batzuetan emaitza berdintsuak ikusi ziren hezur-adina neurtzen duen Tanner-Whitehouse II. metodoa aplikatzean; heltze-maila altuagoa zuten 12-15 urte bitarteko jokalariek heltze baxuagoa zutenek baino tamaina handiagoa izateaz gain, proba fisikoetan ere emaitza hobeagoak lortu zituzten (Malina eta lank., 2000; Vaeyens eta lank., 2006). Beste kirol batzuetan ere, hockeya kasu, emaitza antzekoak lortu dira: eliteko jokalariak handiagoak ziren eta froga fisikoetan emaitza hobeagoak izan zituzten (Sherar eta lank., 2007).

1.5.2. Adin erlatiboaren eragina

Aldagai hauetaz gain, kontuan hartu behar den beste faktore bat da umeak kronologikoki banatzen direla kirolean zein hezkuntzan, hain zuzen ere, haien jaiotze-dataren arabera. Hau horrela izanda, talde berean ia urte beteko desberdintasuna duten umeak aurkitu ditzakegu. Horrela, populazio orokorrean jaiotzak urtean zehar era homogeneo batean ematen badira ere, kirolean banaketa hau modu zeihar batean ematen da. Beraz, ikerketa desberdinek baieztatu dute jokalarien selekzioa burutzean beste fenomeno batek eragina duela: *adin erlatiboaren eragina*, ingelesez "*Relative Age Effect"* edo *"RAE"* deritzona; hots, kirol askotan ikusi egin da urteko lehenengo hilabeteetan jaiotako jokalarien kopuru-nagusitasuna dagoela kategoria berean jokatzen diren gazteen artean (Barnsley & Thomson, 1988; Cobley, Baker, Wattie, & McKenna, 2009; Helsen, Starkes, & Van Winckel, 2000; Thompson, Barnsley, & Stebelsky, 1991).

Efektu honi buruzko lehen ikerketak aurkeztu zirenetik 80ko eta 90eko hamarkadetan (Barnsley, Thomson, & Barnsley, 1985; Barnsley & Thomson, 1988; Barnsley, Thomson, & Legault, 1992; Thompson eta lank., 1991) gaur egun arte, kirol desberdinetan deskribatu izan da lehen hilabeteetan jaiotako kirolarien kopuru-nagusitasuna: futbolean (Carling eta lank., 2009; Mujika, Vaeyens, eta lank., 2009; Vaeyens, Philippaerts, & Malina, 2005), hockeyan (Baker & Logan, 2007; Baker, Schorer, Cobley, Schimmer, & Wattie, 2009; Sherar eta lank., 2007), saskibaloian (Torres-Unda eta lank., 2013), atletismoan edo beisbolean (Thompson eta lank., 1991). Hala ere, efektu hau ez da kirol guztietan ikusi, adibidez, boleibolean edo gimnasian (Baker eta lank., 2009; Baxter-Jones, Helms, Mafulli, Baines-Preece, & Preece, 1995).

Horretaz gain, eragina herrialde desberdinetan ematen dela ikusi da, hala nola, Belgika (Helsen, Starkes, & Van Winckel, 2000), Frantzia (Carling eta lank., 2009), Ingalaterra (Littlewood, Richardson, Gilbourne, & Atkinson, 2005) eta Alemania (Dudink, 1994). Adin gazteetan gertatzeaz gain (Helsen, Starkes, & Van Winckel, 1998) eliteko profesionaletan ere gertatzen dela ere ikusi da (Jiménez & Pain, 2008). Gainera, Vincent eta Glamser-ek (2006) eragina elitezko programa baten barne zeuden jokalari gazteetan aztertzean ikusi zuten gizonezkoetan emakumezkoetan baino nabariagoa zela. Beste autore batzuek antzerako emaitzak lortu dituzte (Mujika, Santisteban, Impellizzeri, & Castagna, 2009; Schorer, Cobley, Büsch, Bräutigam, & Baker, 2008). Beraz, esan dezakegu futbolean lehenengo hilabeteetan jaiotako jokalarien nagusitasuna argia dela. Horrela, Europar herrialdeetan selekzio nazionalen 15, 16, 17 eta 18 urte azpiko kategorietan % 60-70-era iristen dira urtarril, otsail edo martxoan jaiotakoak (Helsen, Van Winckel, & Williams, 2005). Espainiar estatuan egindako ikerketetan ere (Jiménez & Pain, 2008) emaitzak antzekoak izan dira.
Hautaketa partzial hau bultzatzen duten eta kontuan hartu behar diren zenbait aspektu hurrengoak dira:

Alde batetik, lehen aipatu ditugun faktore antropometrikoak. Izan ere, nagusiagoak diren jokalariak tamainaz handiagoak dira eta abantaila fisiko hau errendimendu hobe batean ere islatu daiteke: azkeneko hilabeteetan jaiotako jokalariekin konparatuz azkarragoak dira, potentzia handiagoa dute eta indartsuagoak dira (Gil eta lank., 2010; Helsen, Starkes, & Van Winckel, 2000; Sherar eta lank., 2007). Beste alde batetik, ikaskuntza-faktoreek ere eragina dute. Jokalari hauek hautatuak izatean kalitatezko eta ordu gehiagoko entrenamendua jasotzen dute eta, beraz, jokalari gazteenekiko abantaila dute (Baker eta lank., 2009).

Bukatzeko, faktore genetikoak eta efektu psikologikoak ere kontuan hartu behar dira. Arlo psikologikoari dagokionez, motibazioa indartua izaten da ondo moldatzen diren jokalarien artean; bitartean, haien kide gazteagoek motibazio falta pairatu dezakete; honek guztiak estresa eta ezintasuna bultzatu ditzake (Fairclough & Ridgers, 2010; Wattie, Cobley, & Baker, 2008).

Eragin honek dituen ondorioak desberdinak dira, baina, aitzitik, aukera-desberdintasuna da garrantzitsuena (Musch & Grondin, 2001). Bada, urteko azkeneko hilabeteetan jaiotako jokalariak hautatuak izateko aukera gutxiago dute (Helsen eta lank., 2005). Ez dituztenez aukeratzen, entrenatzen duten ordu-kopurua txikiagoa izaten da, eta, beraz, entrenamendu-kalitatea baxuagoa. Gainera, Vaeyens, Philippaerts eta Malinak (2005) ikusi zuten jokalari hauek partidetan minutu gutxiago konbokaturik izaten zirela eta minutu gutxiago jokatzen zituztela. Horrela, gazteek desilusio eta motibazio-faltagatik utzi egiten diote futbolean jolasteari (Helsen eta lank., 1998). Adibide gisa, Loughborough-eko unibertsitateak egindako txosten baten arabera, 2005.urtean 11 eta 14 urte bitarteko 3.895.000 neska-mutilen artean, 30.000 ez ziren hautatuak izango haien jaiotze-data medio.

2.Helburuak

2. HELBURUAK

Azken urteotan, gazte futbolarien ezaugarriak ezagutzeko ikerketa ugari egin dira, batez ere futbolarien ezaugarri fisikoak eta fisiologikoak aztertzeko. Horretarako, alde batetik, neurketa antropometrikoak burutu zaizkie, eta, bestetik, errendimendua neurtu zaie test desberdinen bitartez. Jokalarien hautaketa-prozesuan eragina duten beste faktore batzuk ere aztertu izan dira: adibidez, heltze-maila eta *adin erlatiboaren eragina*. Hala ere, gutxi dira eliteko talde gazte baten jarraipena burutu duten ikerketak, hots, denboran zehar ezaugarrien aldaketa nolakoa izan den neurtu duten ikerketak.

Lan honen helburu orokorra, maila handiko futbol jokalari gazteen ezaugarri antropometrikoak, fisikoak eta fisiologikoak nolakoak diren ezagutzea izan zen. Horretaz gain, ezaugarri horiek denboran zehar, hau da, hazkundearekin eta heltze prozesuarekin, nola aldatzen diren azaldu nahi izan genuen. Are gehiago, futbol talde profesional batean hautaketa prozesuetan ezaugarri horien garrantzia zein den zehaztu nahi izan genuen.

Era berean, ikerlanaren helburu espezifikoak ondorengo hauek izan ziren:

1. Maila altuan jolasten diren eta garapenean dauden futbolarien ezaugarriak ezagutzea eta ezaugarri horiek adinaren arabera nolakoak diren aztertzea. Besteak beste, ezaugarri antropometrikoak, fisiologikoak eta fisikoak 10-15 urte bitarteko bost adin taldeetan nolakoak ziren aztertu genituen.

2. Maila desberdinetan jolasten diren eta garapenean dauden gazteen artean desberdintasun antropometrikorik dagoen jakitea. Horretarako, konparaketa antropometrikoa burutu genuen lau populazio desberdinen artean: populazio orokorra, futbol talde lokal desberdinetako futbol jokalariak, Athletic Club-aren hautaketa proiektuan (*DENA* proiektua) parte hartu zuten jokalariak eta Athletic Club-eko jokalariak.

3. Lau urteetan zehar maila altuko talde batean jokalarien ezaugarri antropometrikoek, fisiologikoek eta fisikoek jasan zituzten aldaketak neurtzea. Alde batetik, hazkuntza eta heltzearekin erlazionatutako aldagaien garapena nolakoa izan zen ezartzeko eta, bestetik, adin guztietan ezaugarri fisikoek fisiologikoekin zer nolako erlazioa zuten ezartzeko.

4. Futbol profesionalean gertatzen diren hautaketa prozesuak ezagutzea eta maila altuko talde batean jarraitzeko eragin handien duten ezaugarriak zeintzuk diren identifikatzea. Horretarako, lau urteetan zehar maila altuko talde batean kanporatuak izan ziren, taldean gelditu ziren eta taldera etorri ziren jokalari gazteak konparatu genituen.

5. Errendimendu probetan eragin positiboa edo negatiboa duten parametroak identifikatzea. Hau burutzeko, erregresio analisien bidez, adin kronologikoak, tamainak, heltzeak eta neurri antropometrikoek errendimenduzko probetan zuten eragina eta, aldi berean, aldagai hauek proben emaitza aurresateko zuten ahalmena aztertu genuen.

3. Metodologia

3. METODOLOGIA

3.1. Parte-hartzaileak

Ikerketa longitudinal honetan parte hatu zuten subjektuak 1999.urtean eta 1998. urtean jaiotako Athletic Club-eko futbol jokalari gazteak izan ziren. Ikerketa lau denboralditan zehar burutu zen, 2009-2010 denboralditik 2012-2013 denboraldira, alegia. Ikerketaren hasieran jokalarien batez besteko adina 10.92 ± 0.59 urtekoa izan zen.

Denboraldi bakoitzean jokalariak kategoriaz aldatzen ziren. Horrela, lau denboraldietan zehar jokalari batzuk klubean jarraitu zuten, beste batzuk kluba utzi zuten eta, urtero, klubak jokalari berriak hautatu zituen. Hori dela eta, 3.1. Taulan ikusi daitekeen moduan, jokalari kopurua aldakorra izan zen ikerketan zehar.

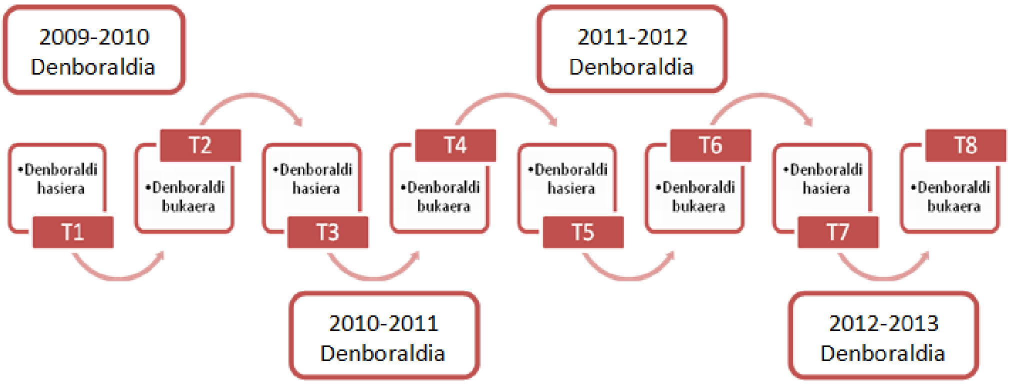
3.1. Taula. Ikerlanean parte hartutako futbol jokalari gazteen kopuru orokorra denboraldiaren eta jaiotze urtearen arabera.

	2009-2010		2010-2011		2011-2012		2012-2013	
	Kategoria	N	Kategoria	N	Kategoria	N	Kategoria	N
1998	Alevin (Under-12)	26	Infantil (Under-13)	20	Infantil (Under-14)	20	Kadete (Under-15)	17
1999	Alevin (Under-11)	27	Alevin (Under-12)	29	Infantil (Under-13)	22	Infantil (Under-14)	17
Guztira		53		49		42		35

N: Jokalari kopurua

3.2. Ikerketaren diseinua

Futbol denboraldi bakoitzean neurketak bi momentu desberdinetan burutu ziren: futbol denboraldiaren hasieran (iraila bukaera - urria hasiera) eta futbol denboraldiaren bukaeran (maiatza bukaera - ekaina hasiera) (ikus 3.1. Irudia). Hori dela eta, ikerketan zortzi neurketa momentu egon ziren. Neurketa momentu bakoitzean proba guztiak bi asteetan zehar burutu ziren.



3.1. Irudia. Ikerketan zehar burutu ziren neurketa momentuak

Neurketa momentu bakoitzean hurrengo probak burutu ziren: antropometria osoa, errendimendu probak (abiadura proba, trebetasun proba, iraupen proba, jauziak eta esku dinamometria), heldutasuna neurtzeko probak eta listu lagin bilketa (hormonen kontzentrazioa neurtzeko, alegia).

Jokalari guztiei hitzordu propioa eman zitzaien antropometria osoa burutzeko. Aldiz, proba fisikoak taldeetan burutu zituzten, hain zuzen ere, klubak zehaztutako egunetan. Izan ere, klubak jokalariei denboraldian zehar hiru alditan burutzen dizkiete errendimendu probak. Proba hauek, klubaren programaketaren barnean daude. Hori dela eta, ikerketa honetarako beharrezkoak ziren neurketak proba hauekin koordinatu ziren.

Honetaz gain, listu lagin bilketa Lezamako aldageletan burutu zen, hain zuzen ere, errendimendu probak burutu ziren egun berdinetan. Lesionaturik egon ziren jokalariei listu lagina hartu zitzaien nahiz eta errendimendu probarik ez egin. Aldiz, gaixo egon ziren jokalariei hitzordua eman zitzaien lagina beste egun batean hartzeko. Ondoren, laginak Medikosta laborategietan eraman ziren eta, aztertu ere, bertan aztertu zituzten. Listu laginak jokalari guztiei hartu zitzaien baina, hala ere, lagin batzuk ezin izan ziren prozesatu ez baitziren prozesatzeko beharrezkoa den lagin minimora heltzen (ikus 3.2. Taula).

Laburbilduz, gaixo edo lesionatuta egon ziren jokalariek ez zituzten hainbat proba burutu eta, era berean, prozesatzeko beharrezkoa zen lagin minimora heltzen ez ziren listu laginak ezin izan ziren aztertu. Hau guztia dela eta, neurketa momentu bakoitzean probetan parte hartu zuten jokalarien kopurua aldakorra izan zen.

3.3. Materiala

Ikerlan hau burutzeko erabili zen tresneria hurrengoa izan zen:

- Tallimetroa: ASIMED Tallímetro portátil de plataforma T226 (Barcelona).
- Seca Quality Seal baskula. Seca gmbh & co. (Alemania).
- Lufkin neurtzeko zinta (Alemania).
- Holtain pakimetroa (Ingalaterra).
- Harpenden plikometroa edo tolesturen konpasa (Ingalaterra).
- Optojump ukipen plataforma, Microgate (Italia).
- Electronic timing lights zelula fotoelektrikoak (Polifemo, Microgate, Italy).
- ALGE TIMING Timer S4 kronometroa (Austria).
- Jamar Hydraulic Hand Dinamometer dinamometroa (Jamar, Bolingbrook, IL, USA).
- Listu laginak biltzeko plastikozko tutuak eta identifikazio etiketak.
- Azukrerik gabeko txikleak.
- *Salimetrics™ testosterone kit*.
- *Salimetrics™ DHEA kit*.

3.4. Metodoak

Ikerketa hau burutzeko kontuan hartu zen ikerlanaren subjektu guztiak 18 urte beherakoak zirela. Hori dela eta, ikerketa hasi baino lehen, burutuko ziren proben inguruko informazio zehatza banatu zitzaien jokalarien gurasoei. Horrela, jokalariek ikerketan parte hartzeko gurasoek edo tutoreek baimena sinatu behar izan zuten (I. Eranskina).

Gurutzetako Ospitaleko Etika Batzordeak ikerketa lan hau onartu egin zuen (II Eranskina).

3.2. Taula. Neurketa momentu bakoitzean probetan parte hartu zuten jokalarien kopuruak.

	Jaiotze urtea	Neurketa momentuak 2009-2010 T0	T1	2010-2011 T2	T3	2011-2013 T4	T5	2012-2013 T6	T7	Guztira
Adin Kronologikoa	1998	26	26	20	20	17	17	20	20	166
	1999	27	27	29	29	22	22	17	17	190
		53	53	49	49	39	39	37	37	356
Altueraren puntako abiadura	1998	26	26	17	20	19	20	10	17	155
	1999	27	28	27	29	23	21	13	17	185
		53	54	44	49	42	41	23	34	340
Antropometria osoa	1998	26	26	19	20	19	20	10	17	157
	1999	25	26	27	27	21	19	11	17	173
		51	52	46	47	40	39	21	34	330
Abiadura proba	1998	24	22	18	19	20	18	17	14	152
	1999	23	25	22	23	17	19	18	14	161
		47	47	40	42	37	37	35	28	313
Trebetasun proba	1998	24	22	18	20	20	19	17	14	154
	1999	23	25	22	23	17	19	18	14	161
		47	47	40	43	37	38	35	28	315
Iraupen proba	1998	16	9	13	16	18	16	16	13	117
	1999	19	20	17	19	14	15	16	12	132
		35	29	30	35	32	31	32	25	249
Jauziak	1998	24	21	18	19	19	18	17	14	150
	1999	23	24	22	23	17	19	18	14	160
		47	45	40	42	36	37	35	28	310
Esku dinamometria	1998	25	25	18	18	16	20	9	17	148
	1999	24	24	25	26	20	19	13	17	168
		49	49	43	44	36	39	22	34	316
Testosterona	1998	26		18	20	20	20	11	16	131
	1999	27		24	28	21	20	10	17	147
		53		42	48	41	40	21	33	278
DHEA	1998	26		19	19	20	20	11	16	131
	1999	27		25	21	25	19	10	16	143
		53		44	40	45	39	21	32	274

DHEA: Dehidroepiandrosterona.

Neurketa momentu bakoitzean datu bilketa bi asteetan zehar burutu zen. Gainera, neurketak estandarizatu egin ziren: proben ordena, proba egiteko ordua eta probak baino lehen egindako beroketa berdintsua izan zen kasu guztietan.

Antropometria probak Athletic Club-eko Lezamako instalazioetan burutu ziren beti ere egoera berdinetan. Horretarako, jokalarien arropa berdintsua izan zen kasu guztietan: futboleko prakak eta barruko arropa. Era berean, errendimendu proba guztiak egoera berdintsuetan burutu ziren Lezamako estalitako pabiloian. Kasu honetan, proba guztietan jokalariek kamiseta, praka motzak eta futboleko botak jantzi zituzten, jauzietan izan ezik, non korrika egiteko botak jantzi zituzten.

3.4.1. Galdeketa

Jokalari bakoitzari galdeketa bat banandu zitzaion betetzeko (II. Eranskina). Galdeketa honetan 3 atal bereizi ditzakegu: datu orokorrak, aurrekari medikoak eta kirol aurrekariak.

Datu orokorrak

Kalkulu estatistikoak egiteko jaiotze-hilabetea erabili zen eta baita ere jaiotze-urtearen seihilekoa eta lauhilekoa. Lau hilekoetan banaketa hurrengoa izan zen: urtarriletik martxora (Q1), apiriletik ekainera (Q2), uztailetik irailera (Q3) eta urritik abendura (Q4). Bi seihilekoen banaketa urtarriletik ekainera (S1) eta uztailetik abendura (S2) izan zen.

Aurrekari medikuak

Jokalariei hurrengo hiru arlo desberdinei buruz galdetu zitzaien: gaixotasun garrantzitsuak, lesioak eta medikazioak.

Kirol aurrekariak

Aurretik praktikatutako kirolei buruz eta galdeketaren momentuan praktikatzen zituzten kirolei buruz galdetu zitzaien: aurretik egondako futbol taldeak, talde horietan egondako denbora eta jolastutako postua eta galdeketaren momentuan, hots, Athletic Club-ean zein postutan jolasten ziren.

2.4.2. Miaketa fisikoa

Antropometria neurketa guztiak ikertzaile berdinak egin zituen ISAK-ek (International Society for the Advancement of Kinanthropometry) gomendatzen duen protokoloari jarraituz (Stewart, Marfell-Jones, Olds, & de Ridder, 2011).

Antropometria eta gorputzaren osagaiak

Pisua

Pisua hurbileko 0.1 kg-tan neurtu zen baskula eramangarri baten bitartez (Seca, Bonn, Germany). Horretarako, jokalariak baskularen erdian jartzen ziren zutik eta aurrera begira, bi oinak elkarren parean zituztelarik eta, beti ere, pisua bi hanketan berdin banatuta.

Altuera

Altuera hurbileko 0.1 cm-tan neurtu zen tallimetro eramangarri baten bitartez (Añó Sayol, Barcelona, Spain). Horretarako, vertex-aren (buruaren punturik altuenaren) eta euste-planoaren arteko distantzia neurtu zen.

Neurketa ondo burutzeko, jokalariak oinak elkarren ondoan izan behar zituzten eta orpoak, ipurmasailak eta bizkarraren goiko aldea eskalarekin kontaktuan. Buruari dagokionez, aurrera begira izan behar zuten Frankfort-en planoa mantenduz. Horretarako, orbitaren beheko ertzetik kanpoko entzunbidearen goialdera doan irudizko lerro bat imajinatu behar da. Lerro hau lurrarekiko paraleloa izan behar da. Bukatzeko, jokalariek arnasketa sakon bat egiten zuten eta orduan neurtzen zen altuera.

Altuera jesarrita

Tallimetroarekin neurtzen zen cm-tan. Jokalariak tallimetroaren eskalaren kontra zegoen 50 cm-tako banku batean jesartzen ziren aurrera begira eta bizkarra zuzen eskalaren kontra jarrita. Aurrekoan bezala, buruak Frankfot-en planoan jartzen zen eta neurketa inspirazioa egitean burutzen zen.

Azal tolesturak

Plikometro batekin azalaren eta larruazalpeko gantzaren lodiera mm-tan neurtu zen. Markatutako puntu bakoitzean bi edo hiru neurketa egin ziren eta batez besteko neurria kalkulatu zen. Hasteko, larruazalpeko gantzaren tolestura bikoitz bat sortzeko ezkerreko eskuaren erpuru eta hatz-erakuslearen artean azal tolestura hartzen zen. Ondoren, eskumako eskuarekin plikometroa hartzen zen, hain zuzen ere, neurtuko zen tolesturatik 1-2 cm-tara eta tolesturarekiko 90º-tara. Neurketa plikometroa jarri eta 2 s-tara egin zen. Gorputzeko sei tokitan hartu ziren neurriak, denak gorputzeko eskuinaldean.

1. Tolestura trizipitala: akromion eta erradioaren buruaren arteko erdiko puntuan neurtzen zen, hots, besoaren atzealdean. Tolesturaren norabidea bertikala eta besoaren luzera-ardatzarekiko paraleloa zen.
2. Tolestura subeskapularra: tolestura hartzen zen eskapularen beheko angelutik horizontalarekiko 45º-ko angeluarekin, beherantz eta kanporantz 2 cm-tara markatutako puntuan. Norabidea oblikuoa zen.
3. Tolestura supraespinala: tolestura hau bi lerroren gurutzagunean neurtu zen:
    1: aurre goiko arantza iliakoren beherengo aldearen punta eta aurreko galtzarbeko (besapeko) ertzaren arteko lerroa.
    2: gandor iliakoaren gainean dagoen tuberkulu iliakoren hegalaren puntuaren parean egindako lerro horizontala.

    Tolesturaren norabidea zeiharra zen, hots, azalaren berezko norabidea jarraitzen zuen.
4. Tolestura abdominala: tolestura hau zilborraren eskuinaldean hartzen zen, 5 cm-tara. Tolestura bertikala zen, gorputzaren luzera-ardatzarekiko paraleloa.
5. Izterreko tolestura: izterrondoko tolestura eta belaun-hezurraren goialdeko mugaren arteko erdiko puntuan neurtzen zen, izterraren aurrealdean, alegia. Norabidea hankaren luzera-ardatzarekiko perpendikularra zen.
6. Zangoko tolestura: zangoaren barrualdean, zangoak perimetrorik handiena duen tokian neurtu zen. Tolesturaren norabidea bertikala zen eta zangoaren luzera-ardatzarekiko paraleloa.

Tolesturen neurketa burutzeko jokalariak zutik egon ziren, izterreko eta zangoko tolesturak neurtzeko izan ezik; bi tolestura hauetan jokalariak jesarrita egon ziren eta belaunak 90º-ko angeluan tolestuta izan zituzten.

Tolestura hauekin guztiekin eragiketa batzuk egin ziren konparaketa estatistikoak egiteko:

- Tolesturen batura: sei tolesturen batuketa egin zen.
- Gorputz-adarretako tolesturak: tolestura trizipitala, izterrekoa eta zangokoaren batuketa.
- Gorputz-enborreko tolesturak: tolestura subeskapularra, suprailiakoa eta abdominalaren batuketa.

Perimetroak

Neurtzeko zinta erabili zen. Zinta, neurtu nahi zen tokiaren inguruan jartzen zen, sakatu gabe, luzera-ardatzarekiko perpendikularrean. Perimetro guztiak neurtzeko jokalariak zutik zeuden. Perimetro hauek neurtzeko, jokalariak zutik eta erlaxaturik jartzen ziren, besoak gorputzarekiko paralelo zituztelarik.

Gorputzeko sei tokitan hartu ziren neurriak (cm-tan), denak gorputzaren eskuinaldean:

1. Besoko perimetroa erlaxatua: gantz tolestura trizipitala neurtu zen toki berean neurtu zen baina, kasu honetan, atzealdean izan beharrean aurrealdean. Horretarako, besoa 90º-tan tolestuta, humeroa lurrarekiko paralelo, eta erlaxatuta zutela akromioaren eta erradioaren buruaren arteko puntua neurtzen zen.
2. Besoko perimetroa uzkurtuta: bizepsaren uzkurdura maximoa neurtu zen. Horretarako, besoa 90º-tan tolestuta eta humeroa lurrarekiko paralelo zutela ahalik eta uzkurdura handiagoa burutu zuten. Neurketa bizepsaren puntu gorenean hartu zen.
3. Izterreko perimetroa: izterreko gantz tolestura neurtu zen toki berean hartu zen perimetroaren neurria.
4. Zangoko perimetroa: zangoko gantz tolestura neurtu zen toki berean hartu zen perimetroaren neurria, hots, bikiaren zirkunferentziaren puntu maximoan

Diametroak

Puntu biren artean zegoen distantzia neurtzen zen cm-tan. Pakimetroaren adar biak neurtu nahi zen puntutan jartzen ziren. Gorputzeko lau tokitan neurtu ziren diametroak:

1. <u>Humeroko diametro biepikondileoa edo ukondoko diametroa:</u> ukondoan, humeroaren epikondiloa eta epitroklearen arteko distantzia neurtu zen. Horretarako jokalariek ukondoa 90º tolestu zuten.
2. <u>Diametro biestiloidea edo eskumuturreko diametroa:</u> eskumuturrean, erradioaren apofisi estiloidea eta kubituarenaren arteko distantzia neurtu zen.
3. <u>Izterhezurreko diametro bikondileoa edo belauneko diametroa:</u> belaunean, izterrezurraren barruko kondiloaren eta kanpoko kondioloaren arteko distantzia neurtu zen. Horretarako, jokalaria jesarrita zegoen eta belauna angelu zuzenean zeukan.
4. <u>Diametro bimaleolarra edo orkatilako diametroa:</u> orkatilan, maleolo tibiala eta peronearen arteko distantzia neurtzen zen. Hemen ere jokalaria jesarrita zegoen.

Ikerketa honetan, antropometrian neurketa-errorea (ingelesez *technical error of measurement* edo *TEM*) hurrengoa izan zen: % 0.14 altueran, % 0.17 pisuan, % 0.36 gantz-tolesturetan eta % 1.70 gainerako neurketetan.

Gorputzaren osagaiak

Neurri hauek guztiak kontuan hartuta, zenbait eragiketa eta formula erabili ziren gorputz masa indizea (G.M.I.) eta gorputzaren osagaiak (pisua eta honen portzentajeak) kalkulatzeko.

<u>Gorputz masa indizea (G.M.I.)</u> = pisua (kg) / altuera^2 (m).

Gantz portzentajea kalkulatzeko Faulkner-en formula erabili zen (1968):

<u>Gantz portzentajea (%)</u>= 4 azal tolesturen batuketa mm-tan (trizipitala + subeskapularra + suprailiakoa + abdominala) x 0.153 + 5.783

Hezur pisua kalkulatzeko, Rocha-k aldatutako Von Döbeln-en formula erabili zen (1974):

Hezur pisua (kg) = 3.02 x (altuera^2 (m) x eskumuturreko diametroa x belauneko diametroa (m) x 400)$^{0.712}$.

Hondar pisua Würch-en proposamenetik atera genuen (1974):

Hondar pisua (kg) = pisu osoa x 24.1 / 100.

Gihar pisua Matiegka-ren formulatik dator (1921):

Gihar pisua (kg) = pisua – (gantz pisua + hezur pisua + hondar pisua).

Gantz pisua (kg) = gantz portzentajea x pisua / 100.

Hezur portzentajea (%) = hezur pisua x 100 / pisua.

Muskulu portzentajea (%) = gihar pisua x 100 / pisua.

Somatotipoa

Aurreko neurriak kontuan harturik eta Heath eta Carter-en (1967) metodoa erabiliz, jokalarien somatotipoaren hiru osagaiak kalkulatu ziren. Osagai bakoitzak, gorputzaren proportzioak nola banatzen diren azaltzen duen tipologia eredu bati jarraitzen dio: *endomorfia* (loditasunerako joera gailentzen da eta gantz adiposoaren maila altuekin erlazionatuta dago), *mesomorfia* (irmotasunarekin eta gihar eskeletikoarekin erlazionatuta dago, hots, forma atletikoarekin) *eta ektomorfia* (gorpuzkeraren linealtasunarekin erlazionatuta dago). Hiru osagaiak kalkulatzeko ondorengo formulak erabili ziren:

Endomorfia

Osagai hau kalkulatzeko, lehenengo X-ren balioa atera behar da. X izkiak gantz tolestura trizipitala (mm), subeskapularra (mm) eta suprailiakoaren (mm) batuketa adierazten du. X horren balioa hurrengo formulan jarri behar da:

$E = -0.7182 + 0.1451X – 0.00068X^2 + 0.000014X^3$

Endomorfia kalkulatzeko ondorengo formula aplikatu behar da:

Endomorfia = E x (170.18 / altuera).

Mesomorfia

Osagai hau kalkulatzeko ondorengo formula aplikatu behar da:

Mesomorfia = 0.858U + 0.601F + 0.188B + 0.161P + 0.131H + 4.5.

Non:

U= Ukondoko diametroa (cm).

F= Belauneko diametroa (cm).

B= Besoko perimetro zuzendua (cm) = besoko perimetroa - gantz tolestura trizipitala.

P= Zangoko perimetro zuzendua (cm) = zangoko perimetroa - zangoko gantz tolestura.

H = Altuera (cm).

Ektomorfia

Indize Ponderala (IP)-ren arabera egiten da; horretarako ekuazio desberdinak erabiltzen dira:

Non:

IP = altuera / pisuaren √3.

IP = 40.75 baino handiagoa bada--Ektomorfia = (IP x 0.732) – 28.58

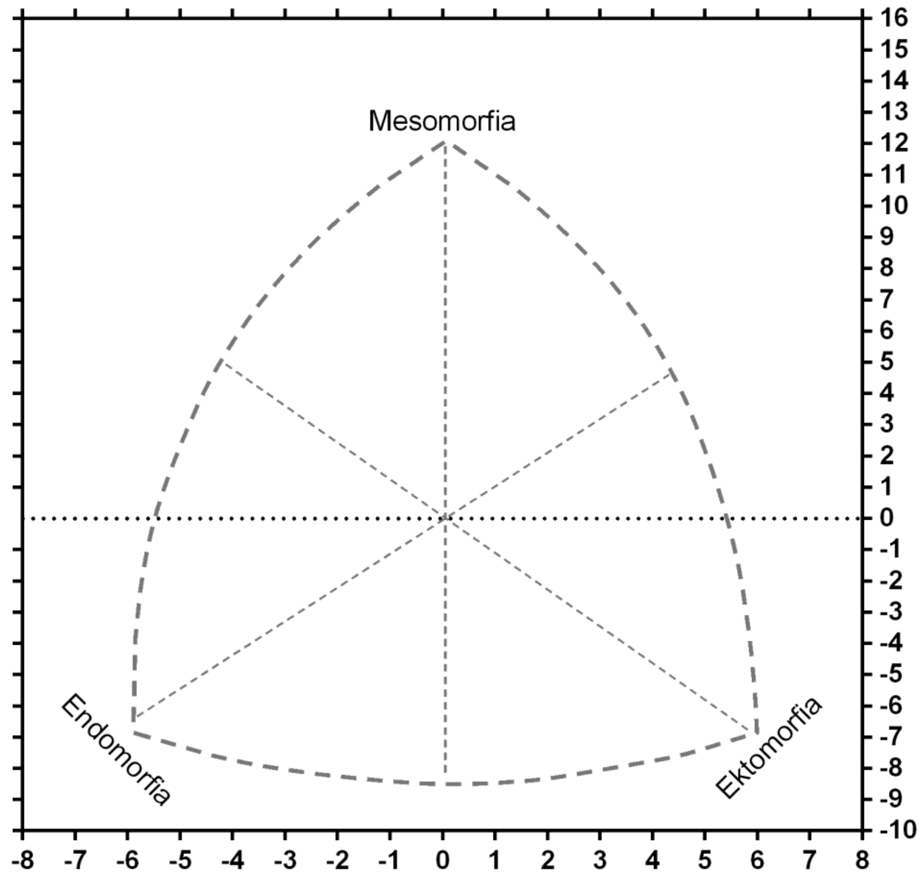
IP = 40.75 eta 38.28 artean badago--Ektomorfia = (IP x 0.463) – 17.63

IP = 38.28 baino txikiagoa bada--Ektomorfia = 0.1.

Gorputz-mapa (somatomapa)

Gorputz-mapa somatotipoaren irudikapen grafikoa da (ikus 3.2 Irudia). Bertan, koordenatuen ardatz baten bitartez somatipoa definitzen duen puntua irudika daiteke. Horretarako, x eta y kalkulatu behar dira jarraian azaltzen den moduan:

- X = Ektomorfismoa – Endomorfismoa
- Y = 2 [Mesomorfismoa – (Endomorfismoa + Ektomorfismoa)



3.2. Irudia. Gorputz-mapa.

Somatotipo kategoriak

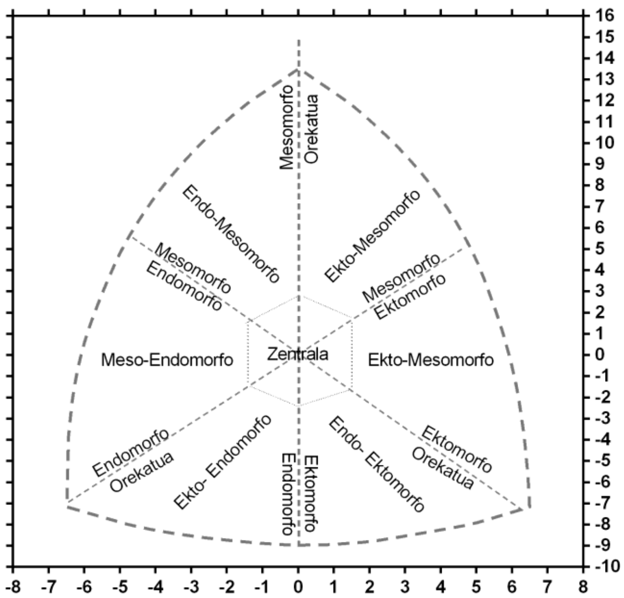
13 kategoria desberdin daude somatotipoan. Hauek guztiak gailentzen den osagaiaren arabera definitzen dira (González & Villegas, 1999) (ikus 3.3. Irudia).

a) Somatotipoa orekatua dela esaten da osagaietako bat beste biengan gailentzen denean eta bi hauen artean 0.5 puntu baino gutxiagoko desberdintasuna dagoenean. Horrela, hiru somatotipo desberdintzen dira: Endomorfia Orekatua, Mesomorfia Orekatua eta Ektomorfia Orekatua.

b) Aldiz, bi osagaik bestea gailentzen dutenean eta, beti ere, haien artean 0.5 baino gutxiagoko desberdintasuna dagoenean, honako hiru kategoriak definitzen dira: Mesomorfia-Endomorfia; Mesomorfia-Ektomorfia eta Ektomorfia-Endomorfia.

c) Gailentzen den osagai bakarra dagoenean baina beste bien artean bat bestarengan gailentzen bada, orduan, sei kategoria definitzen dira: Endo-Mesomorfikoa, Ekto-Mesomorfikoa, Meso-Ektomorfikoa, Endo-Mesomorfikoa eta Ekto-Endomorfikoa. Beraz, gailentzen den osagaia osoa jartzen da eta, bitartean, bigarrena, era laburtuan jartzen da aurrean.

d) Somatotipoa zentrala dela esaten da osagairen bat ez denean besteengan gailentzen eta denek ala denek 4 edo gutxiagoko balorea daukatenean.



3.3. Irudia. Somatotipoen sailkapena.

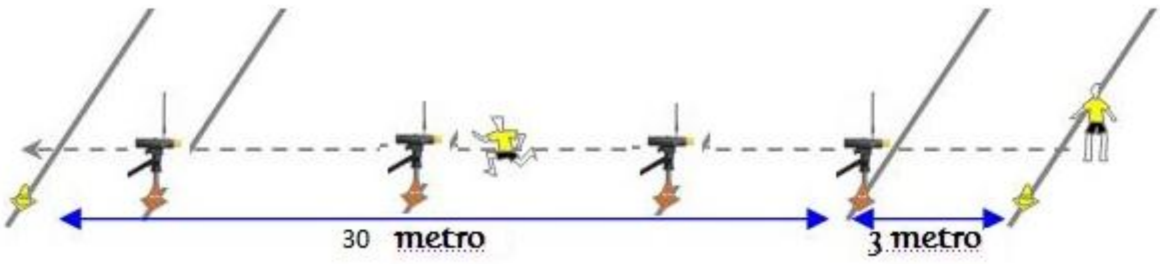
2.3.3. Errendimendu probak

Errendimendu probak ahalik eta egoera berdinetan burutzeko asmoz, jokalari denek beroketa berdina jarraitu zuten.

15-m LEUN

Jokalarien abiadura neurtzeko hamabost metro leun egiterakoan lortzen zuten abiadura maximoa neurtu zen (m/s). Horretarako, zirkuituaren hasieran (0-m) eta bukaeran (15-m) zelula fotoelektrikoak jarri ziren (Polifemo, Microgate, Italia) (ikus 3.4. Irudia). Jokalariak korrika hasten ziren lehen zelula baino hiru metro atzerago zegoen marra batetik. Bidea konoen bitartez markatu zegoen lerro zuzenean korrika egiteko. Jokalariek hitzen bidezko suspertzea jaso zuten proba guztian zehar. Jokalari bakoitzak hiru errepikapen egin zituen, eta neurketa hauetatik denborarik onena kontuan hartu zen (m/s-tan).

Abiadura probaren aldagarritasun-koefizientea (ingelesez *coefficient of variation* edo *CV*) % 95-eko konfiantza-maila erabiliz, % 0.8 eta 4.1 artekoa izan zen.



3.4. Irudia. Abiadura probaren irudikapen grafikoa

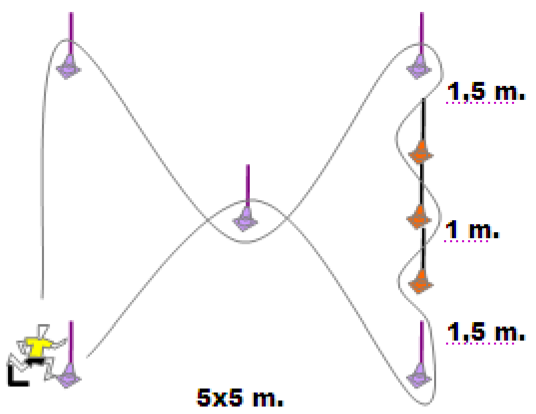
Trebetasun proba

Trebetasuna neurtzeko Barrow-en eraldatutako proba erabili zen (Barrow, 1945). Protokolo honek jokalariek distantzia laburretan mugimendu konplexuak egiteko duten gaitasuna, arintasuna eta bizkortasuna neurtzen du.

3.5. Irudian ikusi daitekeen moduan, proba zirkuitua da eta probaren helburua hau ahalik eta denbora laburrenean burutzea da. Horrela, jokalariak desberdin mugitu behar dira zirkuituan zehar: aurrerantz, atzerantz, sigi-sagan, atzerantz, aurrerantz eta berriro ere aurrerantz. Bukatzeko, hezi baten gainetik egin behar dute salto lateralki. Denbora (s) zirkuituaren hasieran eta bukaeran jarritako zelula fotoelektrikoen bitartez neurtu zen (Polifemo, Microgate, Italia). Neurketak burutu baino lehen jokalari guztiak probarekin trebatuta zeuden. Zirkuituaren osagairen bat lurrera bota ezkero saiakera baliogabetzen zen eta jokalariek berriro errepikatu behar zuten.

Jokalari bakoitzak hiru errepikapen egin zituen eta neurketa hauetatik denborarik onena kontuan hartu zen (s-tan).

Trebetasun probaren aldagarritasun-koefizientea (*CV*) ikerketan zehar % 95-eko konfiantza-maila erabiliz % 1 eta 2.4 artekoa izan zen.



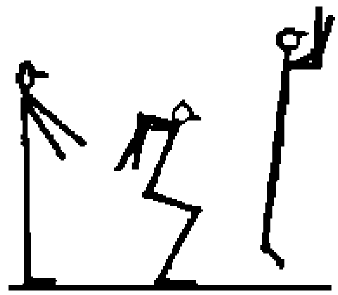
3.5. Irudia. Trebetasun probaren irudikapen grafikoa.

Jauziak

Beheko gorputz-adarretako indar esplosiboa neurtzeko jokalariek besoen ekintzarekin aurkako jauzia edo, ingelesez, *"counter-movement jump, CMJ*" burutu zuten (ikus 3.6. Irudia). Jauzia burutzeko jokalariek hurrengoa egin behar zuten: lehenengo, proba zutik hasi oin-zolak lurrarekin kontaktuan jarrita; gero, belaunak 90º-tara tolestu eta, jarraian, gelditu gabe, jauzi bertikala egin. Besoak aske eramaten zituzten mugimenduak askatasunarekin burutzeko.

Jauzia neurtzeko ukipen plataforma erabili zen (Optojump, Microgate, Italia). Plataformak jokalariak jauzia burutzen duenean airean dagoen denbora tartea eta oinak plataformarekin kontaktuan dauden denbora neurtzen du. Ondoren, jauziaren altuera kalkulatzen du (cm-tan). Jokalari bakoitzak bost jauzi burutu zituen. Bost jauzi hauetatik onena eta txarrena ez ziren kontuan hartu. Ikerketarako, beste hiru jauzien artean onena (cm-tan) erabili zen.

Jauziaren aldagarritasun-koefizientea (*CV*) ikerketan zehar % 95-eko konfiantza-maila erabiliz % 0.9 eta 5 artekoa izan zen.



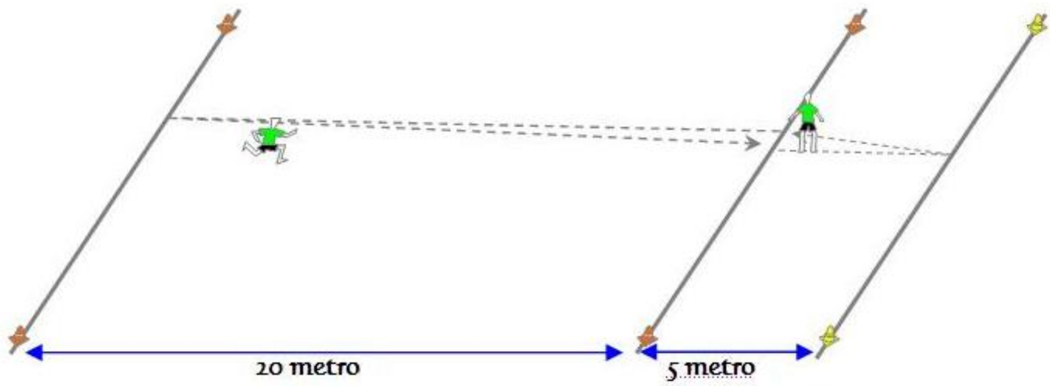
3.6. Irudia. CMJ-ren irudikapen grafikoa.

Iraupeneko proba

Yo-Yo Etengabeko Suspertze Testa 1go Maila (*Yo-yo Intermittent Recovery Test* edo *Yo-Yo IR1*) izan zen erresistentzia neurtzeko erabili zen proba.

Iraupeneko proba honetan jokalariek 2x20 m-tako bi luze korrika egiten dituzte (joan, buelta eman eta etorri) (ikus 3.7. Irudia). Bi luzeak egin ostean, 10 s-tako suspertze denbora tartekatzen dute. Proba igarotzen doan neurrian, abiadura azkartzen doa (hau guztia audioko seinale baten bitartez kontrolatzen da). Jokalariek abiadura mantendu ahal duten arte korrika egiten dute. Proba bukatzen da jokalariek korrika egiteari usten diotenean edo bi alditan ez baldin badira bukaerako marrara denboraren barruan heltzen. Probak neurtzen du jokalariek korrika egiteari utzi edo bukaerako marrara heldu ezin izan duten momenturarte egin dituzten metroak. Beraz, probak jokalariek egin duten distantzia neurtzen du (m-tan).

Neurketa momentu bakoitzean jokalariek proba behin bakarrik burutzen zuten. Hori dela eta, ezin izan zen Yo-Yo IR1-aren konfiantza-maila neurtu. Hala ere, beste autore batzuek probaren aldagarritasun-koefizientea (*CV*) % 4.9 dela kalkulatu dute (Krustrup et al., 2003)



3.7. Irudia. Yo-Yo IR1 probaren irudikapen grafikoa.

Dinamometria

Dinamometriak goiko gorputz ataleko indarra neurtzen du (kp-tan). Jokalariak zutik zeudela dinamometroa esku indartsuarekin hartzen zuten, idazteko eta jateko erabiltzen zuten eskua, alegia. Gainera, besoa zuzen mantendu behar zuten eta eskua gerrialdetik behera. Honetaz gain, dinamometroa esku-ahurra eta 4 atzamar eta behatzaren oinarriarekin heldu behar zuten. Seinalea ematen zitzaienean ahalik eta indar gehien aplikatzen zuten. Dinamometroak eragindako indar gorena adierazten zuen. Jokalari bakoitzak bi saiakera burutu zituen eta ikerketan saiakera onena erabili zen (kp-tan).

Dinamometria probaren aldagarritasun-koefizientea (*CV*) ikerketan zehar % 95eko konfiantza-maila erabiliz) % 4.6 eta 5.5 artekoa izan zen.

2.3.4. Heldutasun probak

Adin kronologikoa

Adin kronologikoa kalkulatzeko jokalarien jaiotze data kontuan hartu zen. Adina ezartzeko lehenengo hilabetea urtarrila izan zen eta, aldiz, azkena, abendua. Hau da, eskoletan ikasturteak eta futbol taldeetan kategoriak sailkatzeko erabiltzen den sailkapena berbera erabili zen.

Horrela, jaiotza hilabetearen arabera jokalariak adin kronologikoa txikiagoa edo handiagoa zuten: adibidez, urte bereko martxoan jaiotako jokalariak irailean jaiotakoak baino adin kronologiko handiagoa zuen.

Adinaren araberako altueraren puntako abidaura

Adinaren araberako altueraren puntako abiadura (*age at peak height velocity* edo *APHV*) *maturity offset* deritzon protokoloarekin kalkulatu zen (Mirwald eta lank., 2002). *Maturity offset*-a zehazteko hurrengo aldagaiak beharrezkoak dira: adin kronologikoa, altuera, pisua, altuera jesarrita eta hanken luzera. Horrela, ekuazioaren emaitzak zehazten du pertsona batek bere altueraren puntako abiadura edo altueraren puntako abiadurara (*PHV*-ra) ailegatzeko behar duen denbora; denbora hau, urteetan neurtzen da. Ekuazioa hurrengoa da: - 9.236 + (0.0002708 x (hanken luzera x altuera jesarrita)) + (0.001663 x (adin kronologikoa x hanken luzera)) + (0.007216 x (adin kronologikoa x altuera jesarrita)) + (0.02292 x ((pisua / altuera) x 100)).

Sherar eta lankideek (2005) ikusi zuten *APHV*-aren neurketen aldagarritasun-koefizientea hezur adinean ikusitakoarekin bat zetorrela (Malina, 2011) eta hori dela eta, ondorioztatu zuten *APHV* metodo fidagarria zela gazteen heltze-maila kalkulatzeko.

Hala ere, garrantzitsua da aipatzea *APHV*-aren kalkuluaren doitasuna antropometria neurketengatik eraginda egongo dela. Izan ere, antropometria neurketan aldagarritasun-koefizientea handia baldin bada, *APHV*-aren kalkulua okerra izan daiteke. Gure ikerketan antropometria neurketen aldagarritasun-koefizienteak zuzenak zirela ikusi genuenez, ondorioztatu dezakegu *APHV*-aren kalkulua fidagarria izan zela.

Listu probak

Adin biologikoarekin erlazioa duten parametroen artean listuko testosterona eta DHEA (dehidroepiandrosterona) hormonen kontzentrazioak hautatu ziren. Izan ere, heldutasun biologikoaren inguruan informazioa eskaintzeaz gain, listu bilketa proba ez inbasiboa da.

Proba hau burutzeko lehenik eta behin listu lagin bat hartu zitzaien jokalariei. Lagina talde bakoitzari zegokion proba fisikoen egunean bertan hartu zen, hots, probak hasi baino 30 minutu lehenago. Lagina hartu baino ordu bete lehenago ezin zuten ezer jan.

Behin jokalariak aldageletan bilduta zeudela plastikozko tutu bana eman zitzaien. Listu lagina baliagarria izateko behintzat 2 cm-tako lagina behar denez, listu jarioa laguntzeko jokalari bakoitzari mentazko txiklea eman zitzaien. Ikerketa honen aurretik UPV/EHU-ko ikasleekin beste lan bat burutu zen mentazko txikleak laginen prozesaketan eraginik ez zuela baieztatzeko. Bertan, txikleak laginean inolako aldaketarik sortzen ez zutela ikusi zen.

Listu-laginak batu orduko hartu eta, jarraian, hozkailu batean gorde ziren. Ondoren, laginak Medikosta laborategietara (Erandio) eraman ziren eta bertan -20º C-tan izoztuta gorde ziren prozesatuak izan arte. Laginak prozesatzeko orduan hurrengo pausuak jarraitu ziren: lehenbizi, laginak desizoztu ziren 20-23.3ºC-ko tenperatura lortu arte; ondoren, 3000 rpm-tan zentrifugatu ziren; azkenik, testosterona nertzeko, *Salimetrics™ testosterone kit*-a erabili zen eta, berriz, DHEA neurtzeko, *Salimetrics™ DHEA kit*-a. Kit hauek listuan testosterona eta DHEA neurtzeko erabiltzen diren entzima inmunoproba espezifikoak dira eta izakiekin eta animaliekin ikerketak burutzeko sortu dira.

Kit hauen aldagarritasun-koefizientea % 2.5 eta % 5.3 da *Salimetrics™ testosterone kit*-arentzat *eta Salimetrics™ DHEA kit*-arentzat, hurrenez hurren.

3.3.5. Estatistika

SPSS 18.0 bertsioaren bitartez aztertu ziren emaitzak eta kasu guztietan adierazgarritasun estatistikoa $p< 0.05$-ean ezarri zen.

Orokorrean, ikerketan zehar erabili ziren proba estatistikoak hauek dira:

- Estatistika deskriptiboa erabili zen batez besteko balioak eta hauen desbiderapen estandarrak ezagutzeko.
- Frekuentziak erabili ziren partaidetzaren araberako jokalari kopuruak talde guztiarekiko adierazten zuten portzentajea ezagutzeko.
- Aldagaien normaltasuna konprobatzeko Kolmogorov-Smirnov edo Shapiro-Wilk probak erabili ziren.
- Bi talderen arteko desberdintasuna neurtzeko, datuek normaltasuna betetzen zutenean, student-en t-test parametrikoa erabili zen (*Students t test*); aldiz, datuek normaltasuna betetzen ez zutenean, Mann Whitney proba ez parametrikoa erabili zen.
- Bi talde desberdin baino gehiago konparatzeko eta denboraldietan zehar egon ziren portzentaje aldaketak konparatzeko, datuak parametrikoak zirenean ANOVA testa erabili zen. Desberdintasunak estatistikoki adierazgarriak zirenean eta, bariantzaren arabera, *post-hoc* test desberdinak erabili ziren: bariantza berdinak zituztenean, Scheffé-ren testa; bariantza desberdinak zituztenean, Bonferroni-ren testa. Berriz, datuak ez parametrikoak zirenean, Kruskal-Wallis-en proba erabili zen.
- Bi aldagaien arteko desberdintasunen magnitudearen tamaina eta norabidea deskribatzeko Cohen-en *d* erabili zen (*Cohen´s d*). Desberdintasunak Cohen-en (1988) arabera interpretatu ziren. Horrela *d* txikia (> 0.2 eta < 0.5), ertaina (≥ 0.5 eta < 0.8) edo handia (≥ 0.8) bezala interpretatu zen.

- Aldagai biren arteko erlazioak aztertzeko, aldagaien normaltasuna betetzen zen kasuetan, Pearson-en korrelazio r koefizientea erabili zen; aldiz, aldagaien normaltasuna betetzen ez zen kasuetan, Spearman-en korrelazio koefizientea erabili zen. Aldagaien arteko korrelazioak Evans-en (1996) arabera interpretatu ziren. Horrela r txikia (< 0.40), ertaina (≥ 0.40 eta < 0.80) eta handia (≥ 0.80) bezala interpretatu zen. Gainera, korrelazio partzialak egin ziren aldagaiak kontrolatu nahi izan zirenean.
- Bikotekako analisia erabili zen (*a pair wise analysis*) denboraldi bakoitzean eta denboraldi artean egon ziren aldaketak kalkulatzeko. Aldaketen portzentaje orokorra subjektu guztien bataz bestekoa kontuan hartuta kalkulatu zen.
- Bi noranzkoko errepikatutako ANOVA erabili zen (*two way repeated measures analysis of variance ANOVA*) gelditu, joan eta etorri ziren jokalarien artean konparaketa egiteko. Horrela, neurtu ziren desberdintasunak izan ziren alde batetik, taldeen artekoak (gelditu *vs.* joan/ gelditu *vs.* etorri) eta, bestetik, proba momentuen artekoak (denboraldi hasiera (T0) eta denboraldi bukaera (T1)).
- Erregresio analisi anitza erabili zen (*multiple regression analysis*) proba fisikoetan heldutasun eta hazkuntza aldagaiek zuten ekarpena neurtzeko.

4. Results

CHAPTER 1

ANTHROPOMETRY, PHYSICAL PERFORMANCE AND MATURITY OF YOUNG SOCCER PLAYERS OF THE ATHLETIC CLUB

4. RESULTS

4.1. CHAPTER 1

4.1.1. Introduction

In elite soccer, coaches are constantly looking for the most effective formula for identifying and developing talented young players (Stratton et al., 2004). In this respect, the role of the youth academy within a club is vital in the long-term development of the youngsters (Le Gall et al., 2010). In some clubs, this process assumes special importance, which is the case of the soccer club of the present investigation. The strict recruiting policy in the club dictates that all players need to be either born or developed in the Basque Country, with a total population of less than three million. Thus, the club has a relatively small population pool to do the selection and so, in this framework, the talent identification process and the youth academy policy acquire great importance.

To success in soccer players need to have an optimal combination of a variety of factors such as body size and composition, physical fitness (aerobic and anaerobic fitness among others) and skill, behavioral dimensions, and a good sense of the game, labeled ‘game intelligence’ (Reilly, Williams, et al., 2000; Stroyer, Hansen, & Klausen, 2004). Therefore, providing a complete anthropometrical, physical and maturational profile of the young elite soccer players within the club may help the selection of young players (Williams & Reilly, 2000).

Nevertheless, comparing results in young elite soccer players is not an easy task due to the differences between the diverse age groups. In a studied performed across three age categories in academy-based elite youth soccer players, Le Gall et al. (2010) observed significant differences in several of the anthropometric and physical performance measures dependant on age categories. While these findings were in agreement with those of Vaeyens et al. (2006), they contradict to some extent those observed in other study based on elite academy soccer players where no differences were found (Frank, Williams, Reilly, & Nevill, 1999).

Although studies have previously analyzed the characteristics of young elite soccer players, to date, only a limited number of studies have tried to estimate the anthropometric, physical performance and maturation characteristic of high level pre-adolescent soccer players. Moreover, due to the specificity of the restrictive recruitment policy of the Athletic Club, the present data deals with a special context were the knowledge of the ethnic variability and specific characteristics of the players may be of vital importance for the technical staff and the coaches.

Thus, the aim of the present study was to provide comprehensive information about the anthropometrical, physical and maturational profile of youth elite soccer players of the Athletic Club among the different age groups. In addition, this information may be helpful for other youth elite soccer coaches and technical staff when improving a specific training in a highly selective context and talent identification processes.

4.1.2. Methodology

Study design

The cross-sectional data used for the analysis in this chapter was taken from the longitudinal study performed with youth soccer players attending the Athletic Club during the seasons 2009-2010 to 2012-2013. Thus, data was collected over a total of four seasons, with new players joining the club at the beginning of each season and players leaving the club at the end of each season. Specifically, measurements used for the analysis were performed annually near the start of the competitive season (end of September- beginning of October) and testing took place at the same time of the day and the same external conditions.

The following measurements were taken: complete anthropometry (height, body mass, sitting height, 4 circumferences (relaxed arm, flexed arm, thigh and leg), 4 diameters (elbow, wrist, knee and ankle), 6 skinfolds (tricipital, subescapular, suprailiacal, abdominal, thigh and leg) and physical performance tests (velocity 15-m sprint (velocity), Barrow agility test (agility), Yo-Yo intermittent recovery tests (level 1) (Yo-Yo IR1), counter-movement jump (CMJ) and hand dynamometry (dynamometry).
Besides, salivary hormones concentration (testosterone and dehidroepiandrosterone (DHEA)), chronological age (AC) and age at peak height velocity (APHV) were calculated (Mirwald et al., 2002).

Sample

The sample were 178 players of the Athletic Club divided in 5 different age groups: players from Under-11 teams (U11), Under-12 teams (U12), Under-13 teams (U13), Under-14 teams (U14) and Under-15 (U15) teams. The number of players analyzed in each age group and their average age are shown in Table 4.1.1.

Table 4.1.1. Number of players in each age group and their average age (mean ± SD).

	Under-11	Under-12	Under-13	Under-14	Under-15
N	27	55	42	37	17
CA (years)	10.40 ± 0.28	11.46 ± 0.29	12.32 ± 0.31	13.35 ± 0.27	14.33 ± 0.27

N: number of players; CA: Chronological age

Statistical Analysis

Descriptive statistics for all measures in each age group are presented as mean ± standard deviation. To determine differences between age groups one-way analysis of variance was used. If significant main effects or interactions were present a Bonferroni post-hoc analysis was conducted. To examine how selected growth and maturation variables and physical performance were interrelated, Pearson's or Spearman´s product-moment and a partial correlation to control age were performed. Significance for all the statistical tests was set at $p< 0.05$.

4.1.3. Results

4.1.3.1. Differences between age groups

Anthropometry, body composition and somatotype

Height, body mass and BMI

Mean measures related to body size (weight, height, sitting height, leg length) and BMI are shown by age in Table 4.1.2. and Figures 4.1.1. to 4.1.5. A significant main effect for age was found in all the variables ($p< 0.001$).

All measures related to body size showed significant differences across all age groups with the exception of weight between U11-U12 players and leg length between U12-U13 and U14-U15 players. No differences were found in BMI between the consecutive age groups.

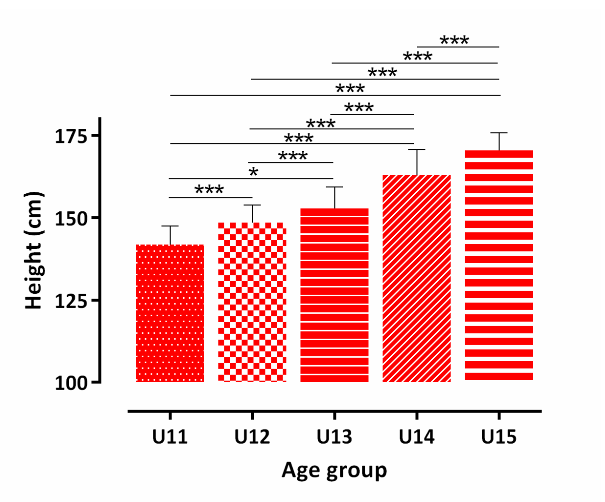


Figure 4.1.1. Differences in height between the age groups.
Error bars represent standard deviation.
***p < 0.001; *p < 0.05

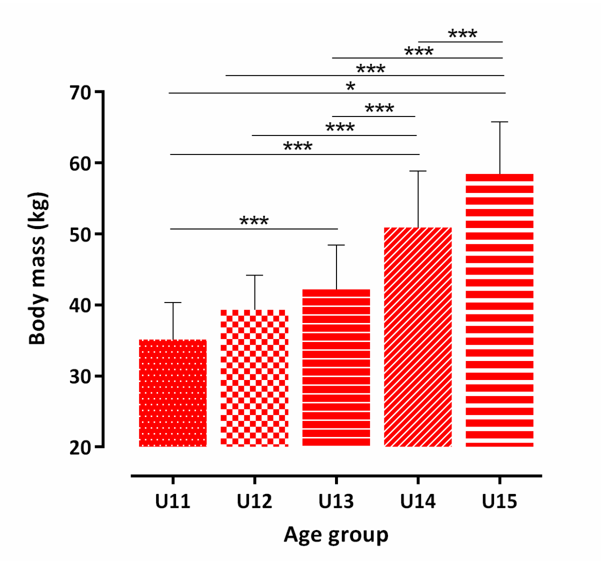


Figure 4.1.2. Differences in body mass between the age groups.
Error bars represent standard deviation.
***p < 0.001; *p < 0.05

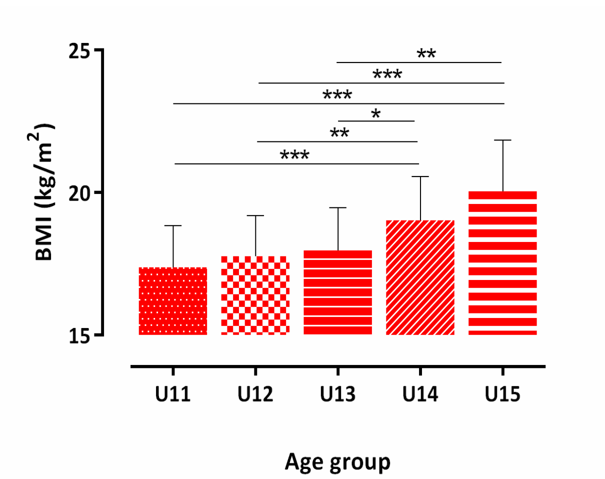


Figure 4.1.3. Differences in body mass index between the age groups.
Error bars represent standard deviation.
***p < 0.001; **p < 0.01; *p < 0.05

Table 4.1.2. Body size related variables and BMI of all the players within each age group at the start of the season (mean ± SD).

	Under-11 (N=25)	Under-12 (N=53)	Under-13 (N=37)	Under-14 (N=30)	Under-15 (N=10)	ANOVA
Height (cm)	141.85 ± 5.68	148.51 ± 5.40	152.88 ± 6.45	163.04 ± 7.70	170.51 ± 5.20	$F_{4,\ 153}$= 66.76, p<0.001, η^2 = 0.64
Body mass (kg)	35.14 ± 5.16	39.30 ± 4.90	42.19 ± 6.21	50.92 ± 7.95	58.43 ± 7.32	$F_{4,\ 153}$= 43.92, p<0.001, η^2 = 0.53
Sitting Height (cm)	70.00 ± 3.15	72.91 ± 2.98	75.39 ± 3.75	78.51 ± 4.79	84.53 ± 3.55	$F_{4,\ 153}$= 40.52, p<0.001, η^2 = 0.51
Leg length (cm)	71.85 ± 3.60	76.43 ± 3.42	79.91 ± 3.95	84.53 ± 4.41	85.98 ± 3.46	$F_{4,\ 153}$= 53.25, p<0.001, η^2 = 0.58
BMI (cm/kg^2)	17.38 ± 1.46	17.77 ± 1.44	17.97 ± 1.50	19.04 ± 1.52	20.05 ± 1.79	$F_{4,\ 153}$= 9.31, p<0.001, η^2 = 0.19

BMI: Body mass index.

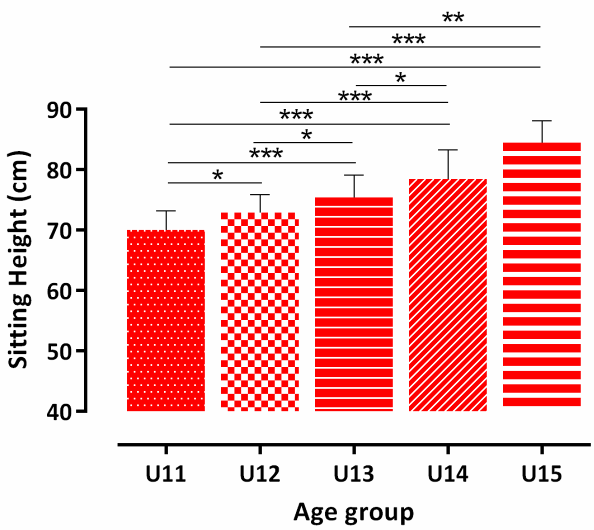


Figure 4.1.4. Differences in sitting height between the age groups.
Error bars represent standard deviation.
***p < 0.001; **p < 0.01; *p < 0.05

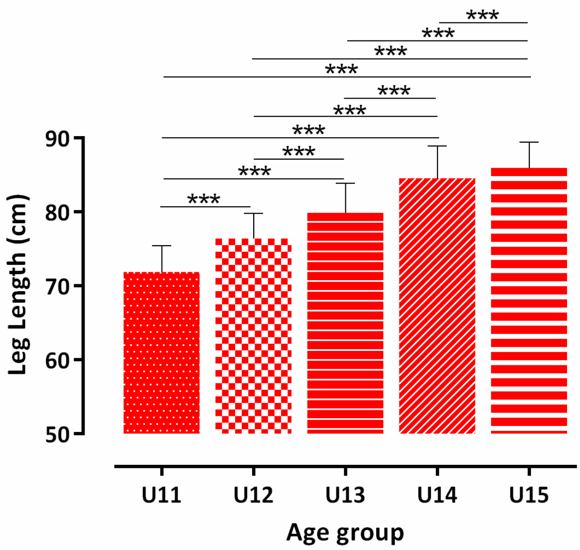


Figure 4.1.5. Differences in leg length between the age groups.
Error bars represent standard deviation.
***p < 0.001

Circumferences and diameters

All the circumferences and the diameters are shown by age in Table 4.1.3. and Figures 4.1.6. to 4.1.13. A significant main effect for age was found in all the variables ($p < 0.001$). All the circumferences were significantly bigger in the U14 and U15 groups compared to the rest of the groups ($p < 0.05$ to 0.001). Nevertheless, non-significant differences were observed between both groups. Similarly, diameters of the elbow and wrist were significantly smaller in the U11 group compared to U13, U14 and U15 groups ($p < 0.01$ to 0.001) while diameters of the knee and ankle were significantly smaller compared to the rest of the groups ($p < 0.001$).

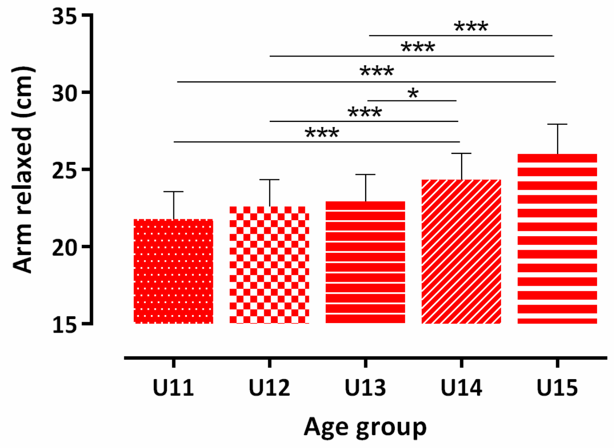


Figure 4.1.6. Differences in relaxed arm circumference between the age groups. Error bars represent standard deviation. ***p < 0.001; *p < 0.05

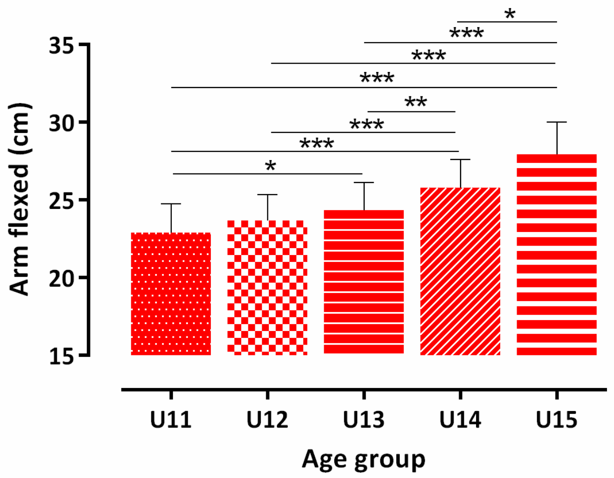


Figure 4.1.7. Differences in flexed arm circumference between the age groups. Error bars represent standard deviation. ***p < 0.001; **p < 0.01; *p < 0.05

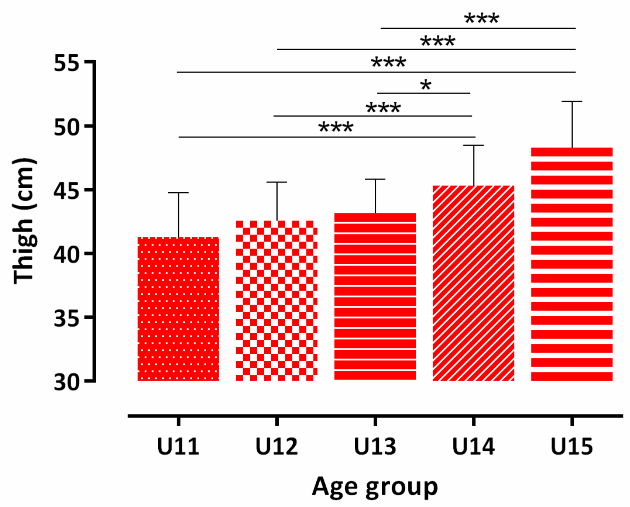


Figure 4.1.8. Differences in thigh circumference between the age groups. Error bars represent standard deviation. ***p < 0.001; *p < 0.05

Table 4.1.3. Circumferences and diameters of all the players within each age group at the start of the season (mean ± SD).

		Under-11 (N=25)	Under-12 (N=53)	Under-13 (N=40)	Under-14 (N=30)	Under-15 (N=10)	ANOVA
Circumferences (cm)	Arm relaxed	21.78 ± 1.79	22.62 ± 1.71	22.94 ± 1.75	24.33 ± 1.71	26.03 ± 1.92	$F_{4, 153}$= 15.30, p<0.001, η^2 = 0.28
	Arm flexed	22.90 ± 1.85	23.69 ± 1.66	24.35 ± 1.78	25.79 ± 1.81	27.94 ± 2.06	$F_{4, 153}$= 21.04, p<0.001, η^2 = 0.35
	Thigh	41.26 ± 3.48	42.56 ± 3.03	43.15 ± 2.68	45.33 ± 3.13	48.31 ± 3.59	$F_{4, 153}$= 13.38, p<0.001, η^2 = 0.25
	Leg	28.71 ± 2.02	30.44 ± 3.00	31.11 ± 2.25	33.10 ± 2.65	33.43 ± 2.25	$F_{4, 153}$= 12.80, p<0.001, η^2 = 0.25
Diameters (cm)	Elbow	5.63 ± 0.29	5.81 ± 0.39	6.12 ± 0.41	6.53 ± 0.37	6.72 ± 0.36	$F_{4, 153}$= 33.59, p<0.001, η^2 = 0.46
	Wrist	4.52 ± 0.27	4.67 ± 0.28	4.92 ± 0.28	5.17 ± 0.34	5.31 ± 0.31	$F_{4, 153}$= 28.51, p<0.001, η^2 = 0.42
	Knee	7.65 ± 0.38	8.51 ± 0.64	9.31 ± 0.45	9.64 ± 0.40	9.82 ± 0.48	$F_{4, 153}$= 75.80, p<0.001, η^2= 0.66
	Ankle	5.20 ± 0.34	5.97 ± 0.65	6.67 ± 0.68	6.91 ± 0.36	7.09 ± 0.25	$F_{4, 153}$= 47.39, p<0.001, η^2 = 0.55

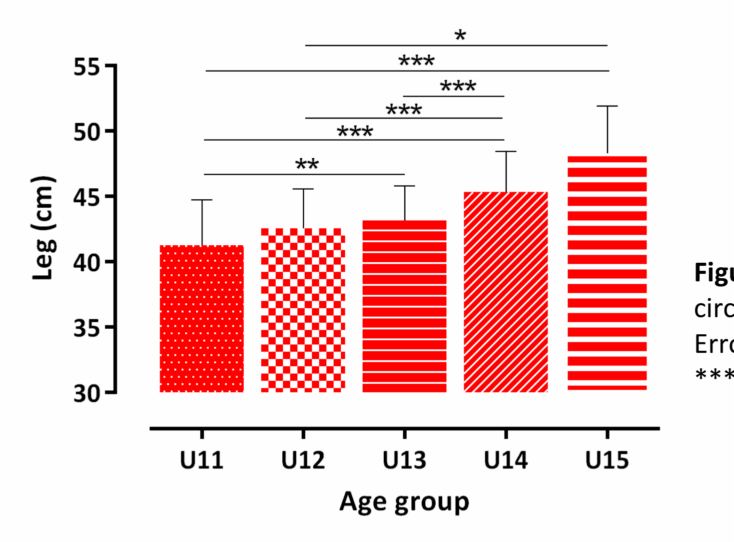


Figure 4.1.9. Differences in leg circumference between the age groups. Error bars represent standard deviation. ***p < 0.001; **p < 0.01; *p < 0.05

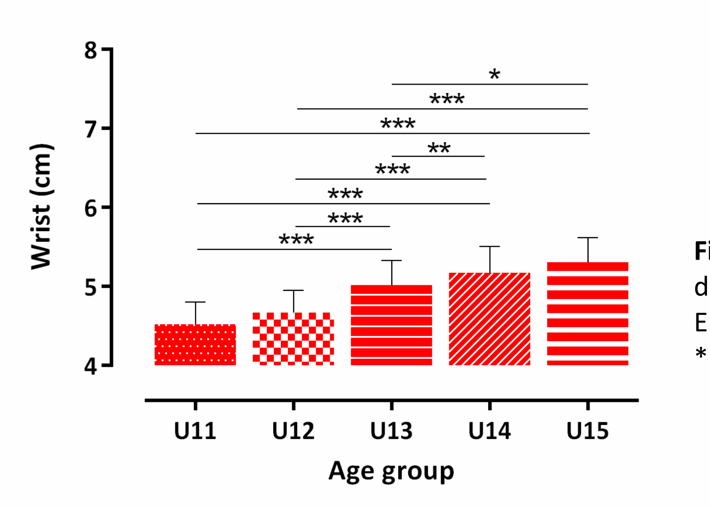


Figure 4.1.10. Differences in wrist diameter between the age groups. Error bars represent standard deviation. ***p < 0.001; **p < 0.01; *p < 0.05

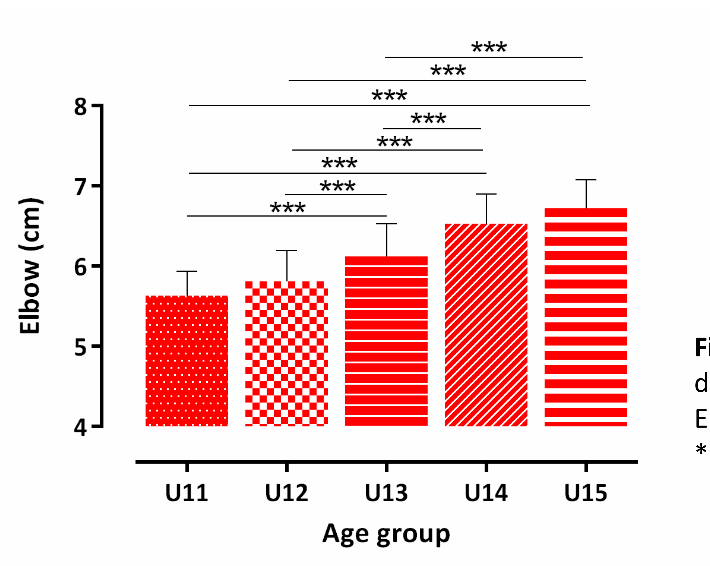


Figure 4.1.11. Differences in elbow diameter between the age groups. Error bars represent standard deviation. ***p < 0.001

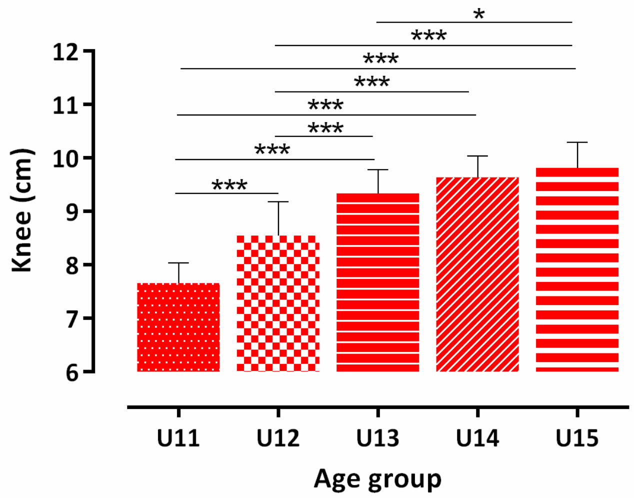


Figure 4.1.12. Differences in knee diameter between the age groups.
Error bars represent standard deviation.
***p < 0.001;*p < 0.05

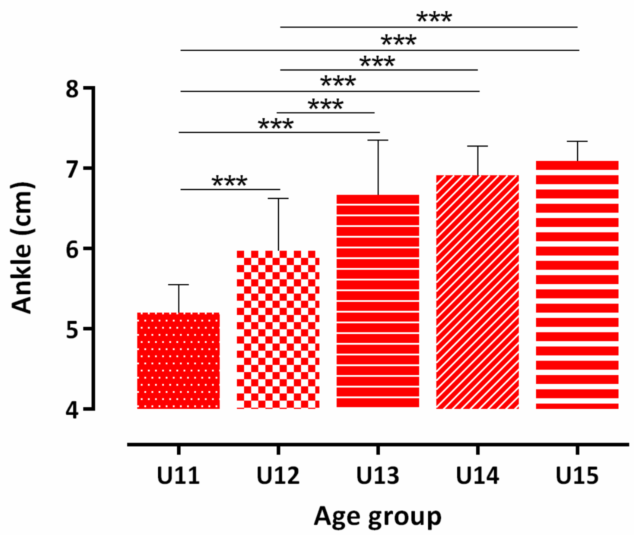


Figure 4.1.13. Differences in ankle diameter between the age groups.
Error bars represent standard deviation.
***p < 0.001

Skinfold thickness

All the skinfold thickness variables are shown by age in the Table 4.1.4 and Figures 4.1.14 to 4.1.22. No differences were found between the age groups in skinfold thickness, with the exception of the thigh and the leg and, consequently, the ∑ extremities skinfold ($p<0.05$ to 0.01). Besides, the thigh and leg skinfolds were smaller in the U15 group compared to the U11 and U12 groups ($p< 0.05$). Also, the U15 group had less skinfold thickness in ∑ extremities compared to the U11 and U12 groups ($p<0.05$).

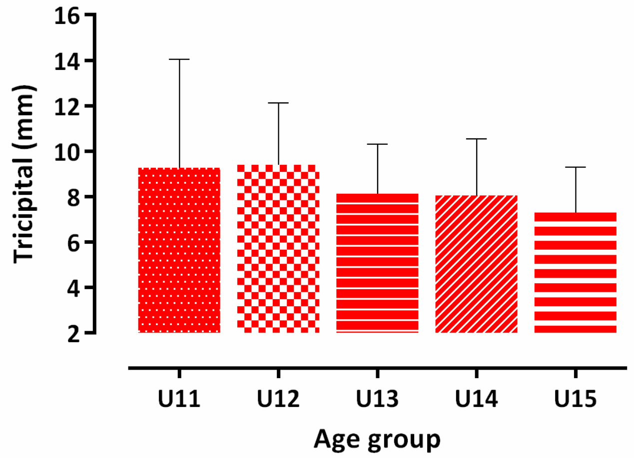


Figure 4.1.14. Differences in tricipital skinfold between the age groups.
Error bars represent standard deviation.

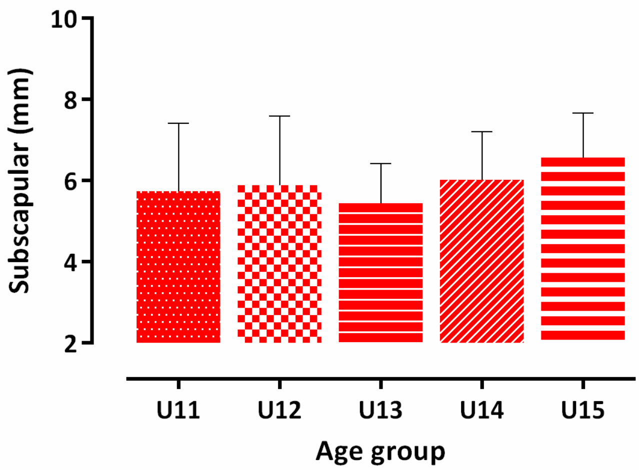


Figure 4.1.15. Differences in subescapular skinfold between the age groups.
Error bars represent standard deviation.

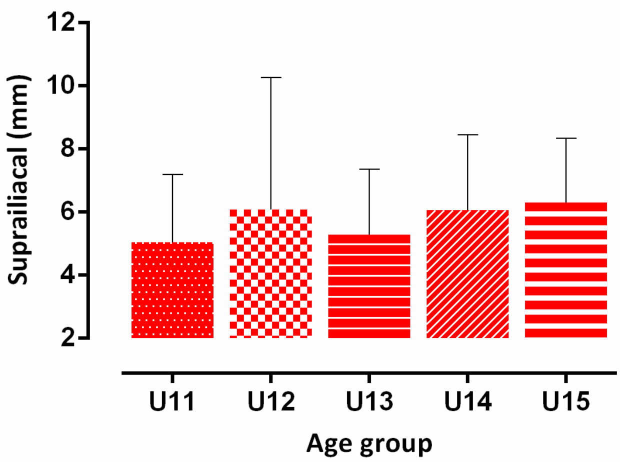


Figure 5.1.16. Differences in suprailiacal skinfold between the age groups.
Error bars represent standard deviation.

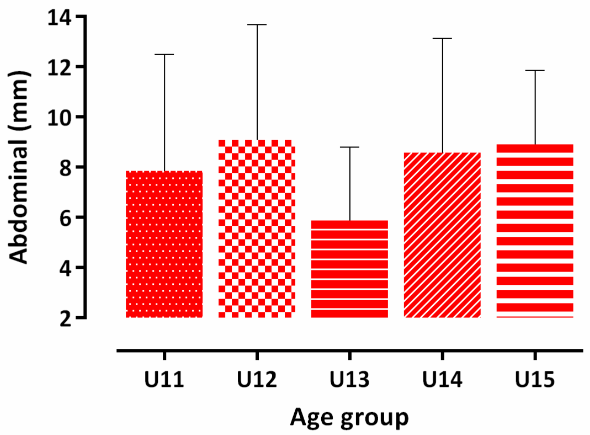


Figure 4.1.17. Differences in abdominal skinfold between the age groups.
Error bars represent standard deviation.

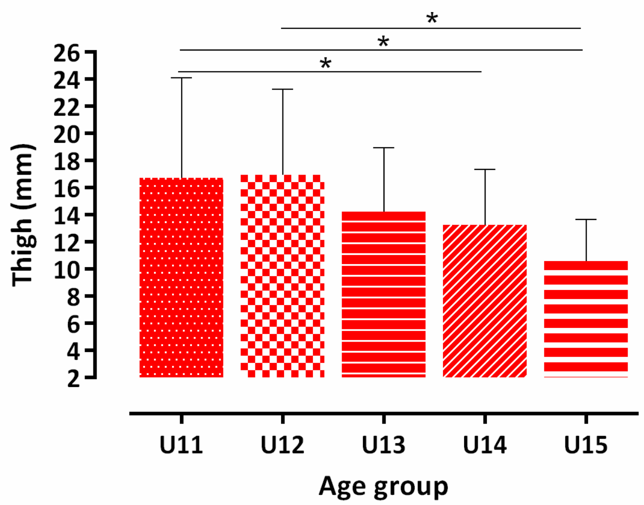


Figure 4.1.18. Differences in thigh skinfold between the age groups.
Error bars represent standard deviation.
*$p < 0.05$

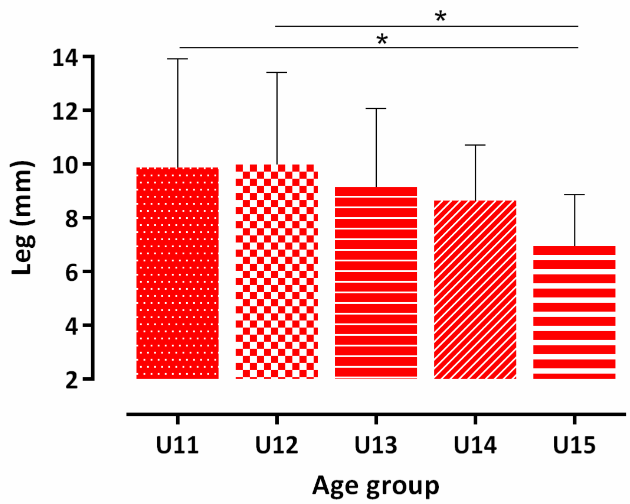


Figure 4.1.19. Differences in leg skinfold between the age groups.
Error bars represent standard deviation.
*$p < 0.05$

Table 4.1.4. Skinfold thickness of all the players within each age group at the start of the season (mean ± SD).

		Under-11 (N=25)	Under-12 (N=53)	Under-13 (N=40)	Under-14 (N=30)	Under-15 (N=10)	ANOVA
Skinfolds (mm)	Tricipital	9.66 ± 6.51	9.39 ± 2.74	8.13 ± 2.18	8.06 ± 2.47	7.31 ± 2.00	$F_{4,\ 153}$= 1.95, p= 0.105, η^2 = 0.04
	Subscapular	5.74 ± 1.67	5.89 ± 1.71	5.45 ± 0.97	6.02 ± 1.19	6.57 ± 1.09	$F_{4,\ 153}$= 1.58, p= 0.182, η^2 = 0.04
	Suprailiac	5.04 ± 2.16	6.08 ± 4.19	5.29 ± 2.07	6.06 ± 2.39	6.31 ± 2.03	$F_{4,\ 153}$= 0.89, p= 0.46, η^2 = 0.02
	Abdominal	7.86 ± 4.63	9.46 ± 5.62	7.74 ± 3.66	8.59 ± 4.54	8.91 ± 2.94	$F_{4,\ 153}$= 0.95, p= 0.43, η^2 = 0.02
	Thigh	16.72 ± 7.39	16.94 ± 6.34	14.27 ± 4.68	13.27 ± 4.07	10.60 ± 3.08	$F_{4,\ 153}$= 4.57, p<0.01, η^2 = 0.10
	Leg	9.88 ± 4.03	9.99 ± 3.43	9.16 ± 2.91	8.66 ± 2.05	6.95 ± 1.93	$F_{4,\ 153}$= 2.62, p<0.05, η^2 = 0.06
	∑ skinfolds	54.90 ± 24.42	57.75 ± 21.49	50.04 ± 13.97	50.60 ± 14.28	46.65 ± 12.00	$F_{4,\ 153}$= 1.58, p= 181, η^2 = 0.04
	∑ trunk Skinfolds	18.64 ± 8.01	21.43 ± 10.94	18.48 ± 6.39	20.67 ± 7.86	21.79 ± 5.82	$F_{4,\ 153}$= 0.96, p= 0.42, η^2 = 0.02
	∑ extremities Skinfolds	36.26 ± 16.91	36.32 ± 11.66	31.56 ± 8.80	29.93 ± 7.68	24.86 ± 6.55	$F_{4,\ 153}$= 3.76, p<0.01, η^2 = 0.09

∑ skinfolds: total sum of skinfold; ∑ trunk skinfolds: sum of trunk skinfolds; ∑ extremities skinfolds: sum of extremities skinfolds.

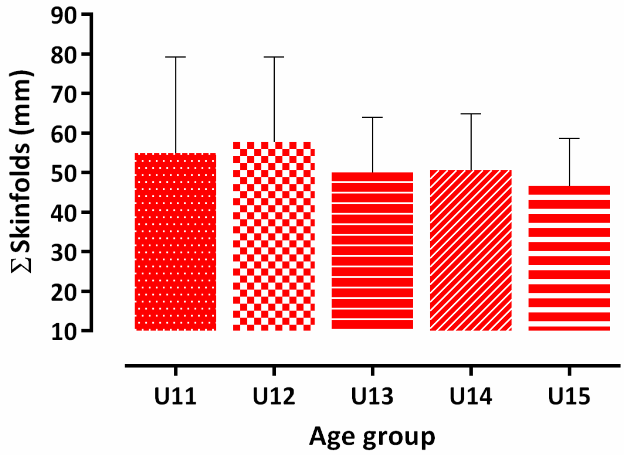


Figure 4.1.20. Differences in ∑ skinfolds between the age groups.
Error bars represent standard deviation.

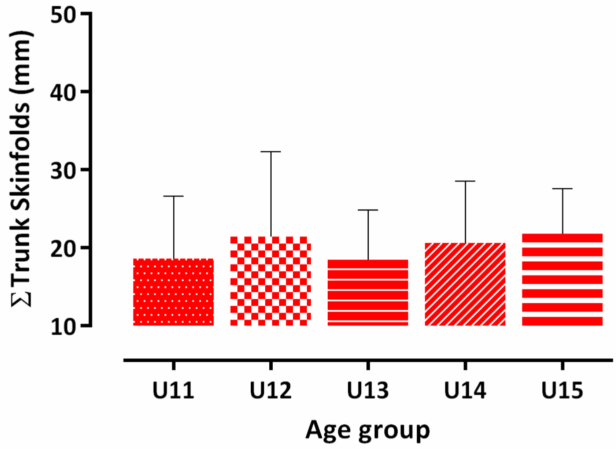


Figure 4.1.21. Differences in ∑ trunk Skinfolds between the age groups.
Error bars represent standard deviation.

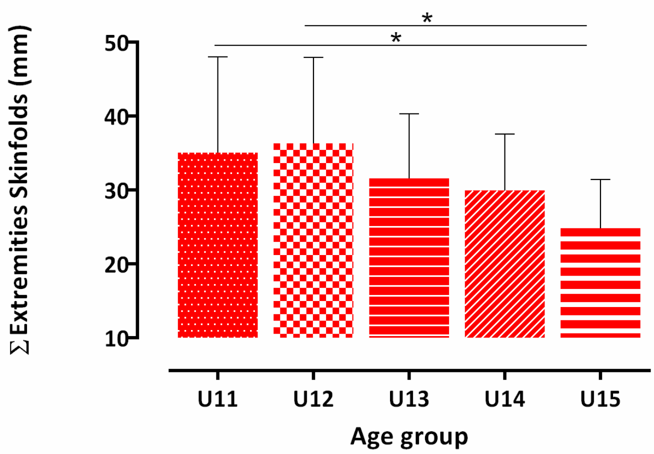


Figure 4.1.22. Differences in ∑ extremities Skinfolds between the age groups.
Error bars represent standard deviation.
*$p < 0.05$

Body composition

Body composition components are shown by age in the Table 4.1.5. and Figures 4.1.23. to 4.1.28. A significant main effect for age was observed in the weight of the body components and in bone and muscle percentages ($p < 0.001$), whereas significance was not found in fat percentage. Looking at the results more closely, it may be observed that the U11 group players had the lowest weight in each component ($p < 0.01$ to 0.001). Also, the U15 and U14 groups had significantly more fat than the rest of the age groups ($p < 0.05$ to 0.001). Regarding component percentages, players of the U11 group had the lowest bone ($p < 0.001$) and the higher muscle percentages ($p < 0.001$).

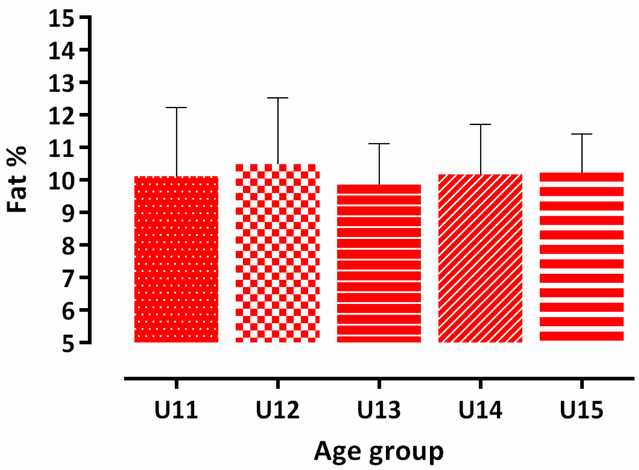


Figure 4.1.23. Differences in fat % between the age groups.
Error bars represent standard deviation.

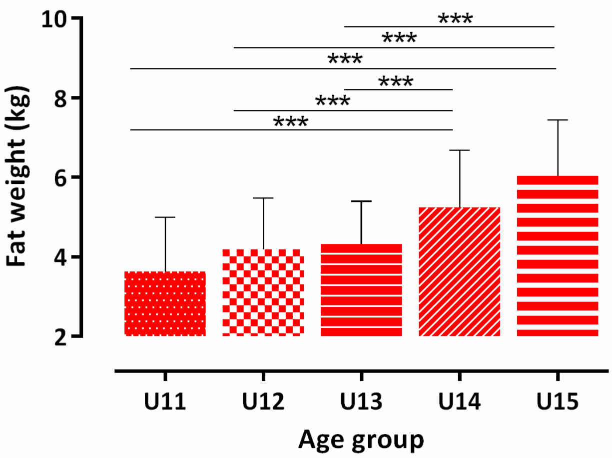


Figure 4.1.24. Differences in fat weight between the age groups.
Error bars represent standard deviation.
***p < 0.001

Table 4.1.5. Body components of all the players within each age group at the start of the season (mean ± SD).

		Under-11 (N=25)	Under-12 (N=53)	Under-13 (N=40)	Under-14 (N=30)	Under-15 (N=10)	ANOVA
Body percentages (%)	Fat	10.11 ± 2.12	10.50 ± 2.03	9.85 ± 1.27	10.17 ± 1.54	10.24 ± 1.18	$F_{4,\ 153}$= 0.79, p= 0.53, η^2 = 0.02
	Bone	17.98 ± 1.13	18.90 ± 1.45	19.99 ± 0.96	19.64 ± 1.27	18.78 ± 1.35	$F_{4,\ 153}$= 11.80, p<0.001, η^2 = 0.23
	Muscle	47.80 ± 1.52	46.50 ± 1.88	46.09 ± 1.07	46.09 ± 1.42	46.88 ± 0.91	$F_{4,\ 153}$= 6.01, p<0.001, η^2 = 0.13
Body weight (kg)	Fat	3.63 ± 1.35	4.19 ± 1.29	4.32 ± 1.07	5.24 ± 1.44	6.04 ± 1.40	$F_{4,\ 153}$= 9.70, p<0.001, η^2 = 0.20
	Bone	6.28 ± 0.70	7.40 ± 0.88	8.66 ± 1.12	9.94 ± 1.28	10.91 ± 1.04	$F_{4,\ 153}$= 71.56, p<0.001, η^2 = 0.65
	Muscle	16.75 ± 2.10	18.23 ± 2.03	20.02 ± 2.92	23.46 ± 3.71	27.39 ± 3.42	$F_{4,\ 153}$= 43.98, p<0.001, η^2 = 0.53

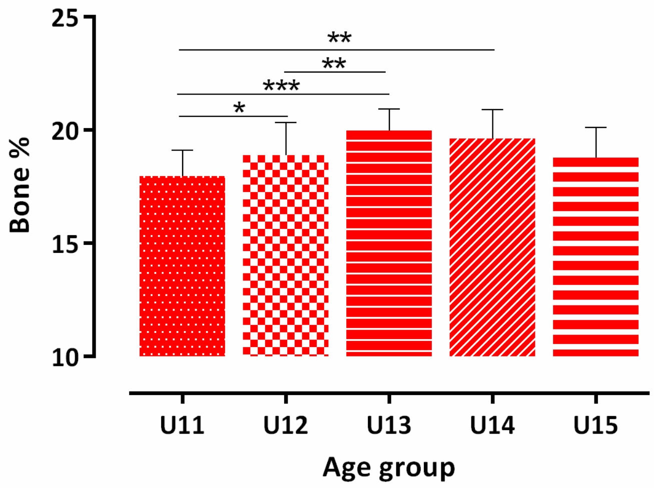


Figure 4.1.25. Differences in bone % between the age groups.
Error bars represent standard deviation.
***p < 0.001; **p < 0.01; *p < 0.05

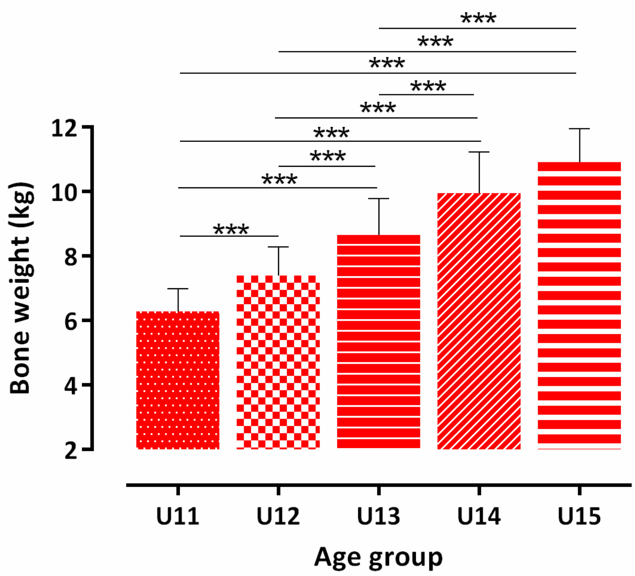


Figure 4.1.26. Differences in bone weight between the age groups.
Error bars represent standard deviation.
***p < 0.001

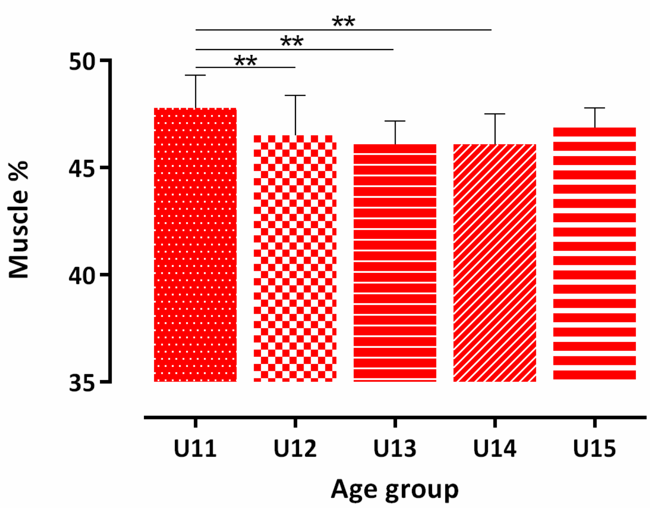


Figure 4.1.27. Differences in muscle % between the age groups.
Error bars represent standard deviation.
**p < 0.01

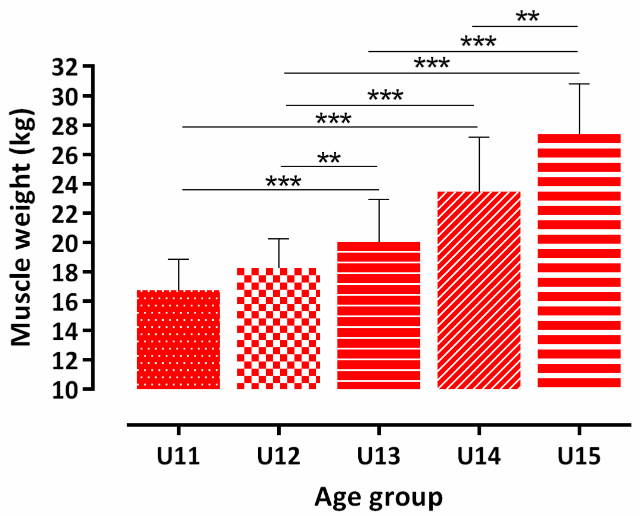


Figure 4.1.28. Differences in muscle weight between the age groups.
Error bars represent standard deviation.
***p < 0.001; **p < 0.01

Somatotype

The mean somatotype of the overall players by age group is shown in Table 4.1.6. No statistically significant differences were observed regarding age. Nevertheless, the U11 group was ecto-mesomorphic while all the rest of the groups tend to be mesomorph-ectomorph. Thus, a predominance of mesomorphy was observed in all the groups. Somatotype distributions of players regarding their age are shown in the somatochart (Figures 4.1.29. and 4.1.30.).

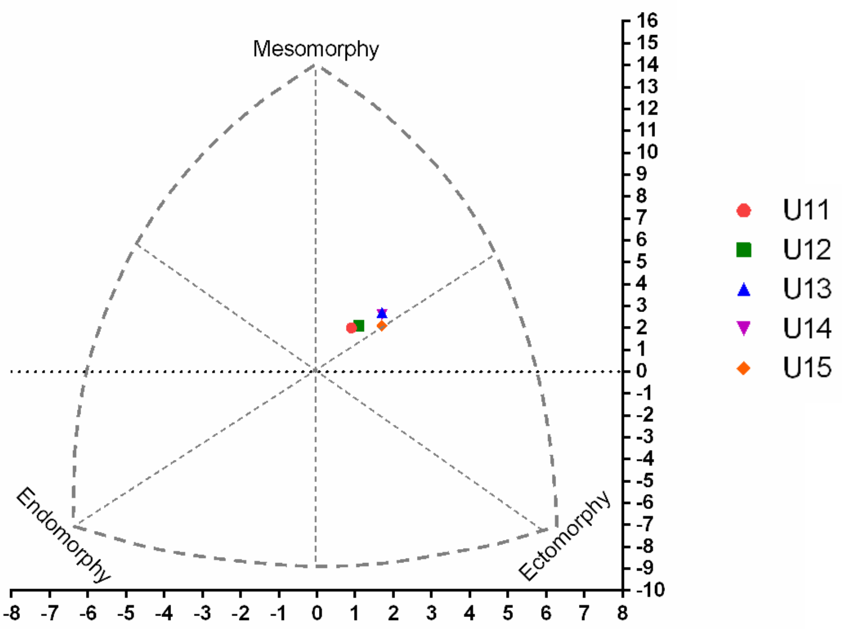


Figure 4.1.29. Somatochart. Somatotype distributions of all the soccer players within each age group.

Table 4.1.6. Somatotype of all the players within each age group at the start of the season (mean ± SD).

	Under-11 (N=25)	Under-12 (N=53)	Under-13 (N=40)	Under-14 (N=30)	Under-15 (N=10)	ANOVA
Endomorphy	2.29 ± 1.15	2.34 ± 0.95	1.95 ± 0.60	1.99 ± 0.62	1.92 ± 0.53	$F_{4,\ 153}$= 1.91, p= 1.11, η^2 = 0.04
Mesomorphy	3.73 ± 0.51	3.96 ± 1.01	4.13 ± 0.73	4.15 ± 0.84	3.86 ± 0.92	$F_{4,\ 153}$= 1.23, p= 0.30, η^2 = 0.03
Ectomorphy	3.20 ± 0.74	3.47 ± 0.82	3.66 ± 0.70	3.71 ± 0.71	3.66± 0.91	$F_{4,\ 153}$= 1.97, p= 1.01, η^2 = 0.04

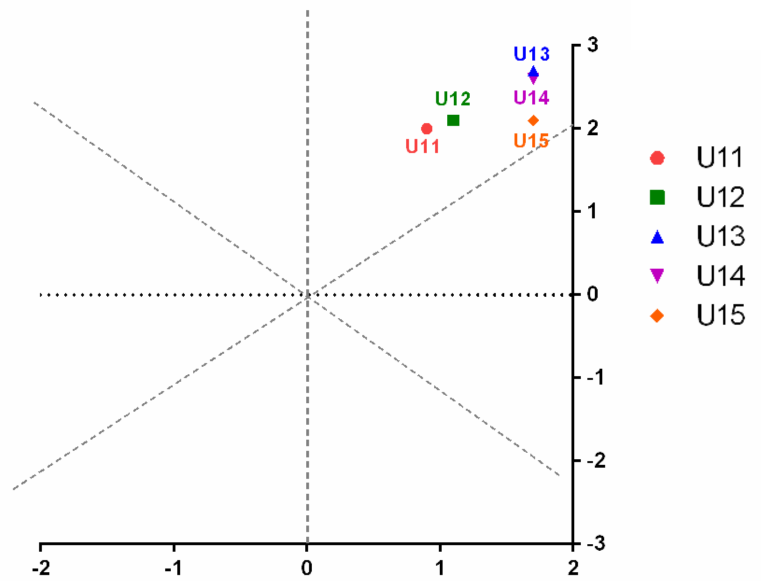


Figure 4.1.30. A closer look of the somatochart

Physical performance

All the physical performance variables are shown by age in Table 4.1.7. A significant main effect for age was found in all the variables (p< 0.001). On the one hand, in the velocity 15-m test (Figure 4.1.31) significant differences were observed across all age groups with the exception of players from the U11 and U12 age groups. Conversely, in the agility test (Figure 4.1.32), there were significant differences between all age groups with the exception of U14 and U15 groups. This trend was also detected in Yo-Yo IR1 test (Figure 4.1.33), where no differences were observed in the two eldest groups. In the CMJ test (Figure 4.1.34), the U14 and U15 age groups were significantly different from all the rest of the groups but, in contrast, no differences were observed between them. Moreover, no differences were detected between U11-U12-13 groups. In opposition, there were significant differences between all the age groups in the dynamometry test (Figure 4.1.35). Overall, there was a trend for all performance variables to improve with increasing age.

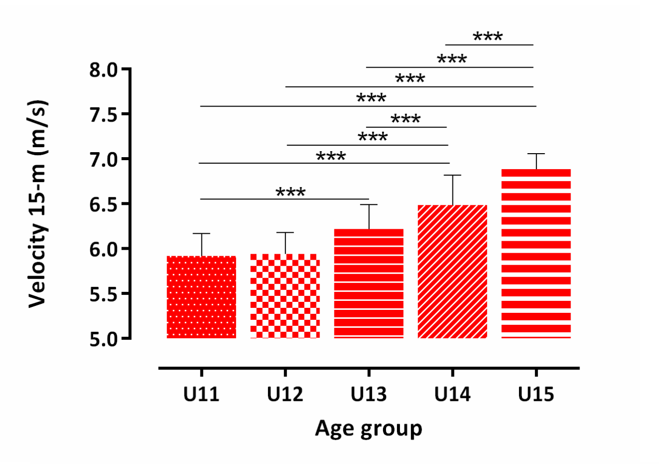


Figure 4.1.31. Differences in velocity 15-m test between the age groups.
Error bars represent standard deviation.
***p < 0.001

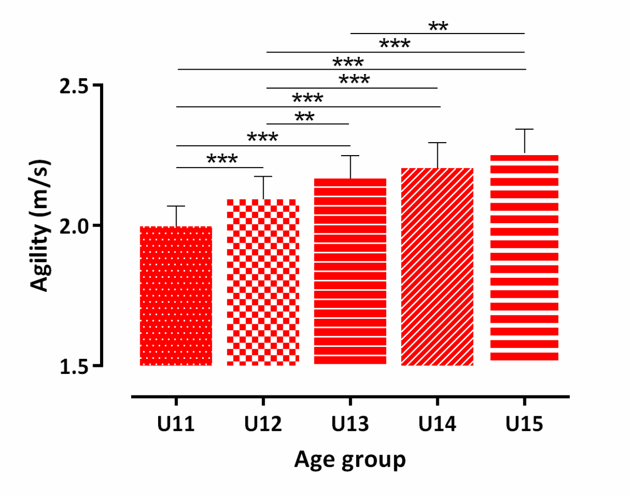


Figure 4.1.32. Differences in the agility test between the age groups.
Error bars represent standard deviation.
***p < 0.001; **p < 0.01

Table 4.1.7. Physical performance variables of all the players within each age group at the start of the season (mean ± SD).

	N	Under-11	N	Under-12	N	Under-13	N	Under-14	N	Under-15	ANOVA
Velocity (m/s)	23	5.91 ± 0.25	46	5.94 ± 0.24	35	6.22 ± 0.27	37	6.49 ± 0.33	17	6.89 ± 0.17	$F_{4, 153}$= 55.77, p<0.001, η^2 = 0.59
Agility (m/s)	23	1.99 ± 0.74	46	2.09 ± 0.81	35	2.16 ± 0.08	37	2.20 ± 0.91	17	2.25 ± 0.08	$F_{4, 153}$= 37.77, p<0.001, η^2 = 0.49
Yo-Yo IR1 (m)	19	675.78 ± 178.33	33	1040.00 ± 315.44	27	1155.56 ± 241.11	34	1368.24 ± 307.13	16	1602.50 ± 299.14	$F_{4, 124}$= 30.39, p<0.001, η^2 = 0.49
CMJ (cm)	23	34.36 ± 4.42	46	32.63 ± 4.66	35	32.63 ± 4.66	35	37.90 ± 4.34	17	41.17 ± 4.71	$F_{4, 152}$= 15.27, p<0.001, η^2 = 0.28
Dinamometry (kp)	24	16.30 ± 2.71	50	24.89 ± 3.84	38	27.32 ± 4.68	29	31.28 ± 5.96	9	40.22 ± 4.29	$F_{4, 145}$= 63.67, p<0.001, η^2 = 0.63

Velocity: velocity 15-m test; Agility: barrow agility test; Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1): CMJ: counter-movement jump; Dynamometry: hand dynamometry.

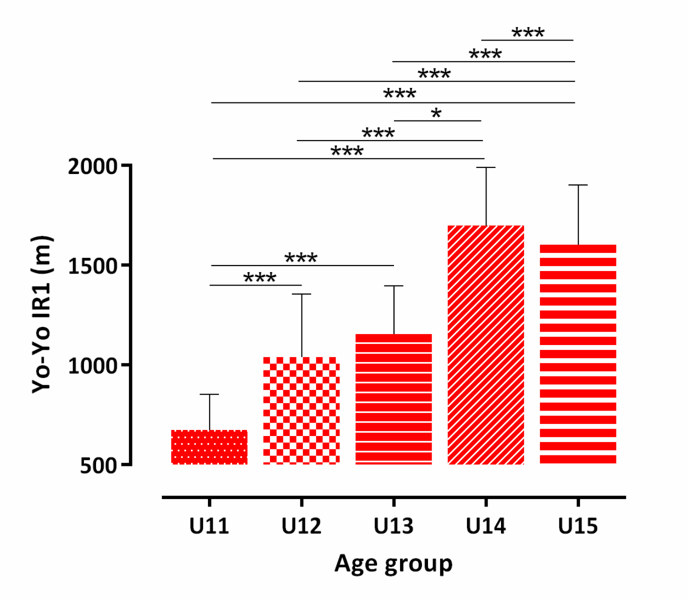


Figure 4.1.33. Differences in the Yo-Yo IR1 test between the age groups.
Error bars represent standard deviation.
***p < 0.001; *p < 0.05

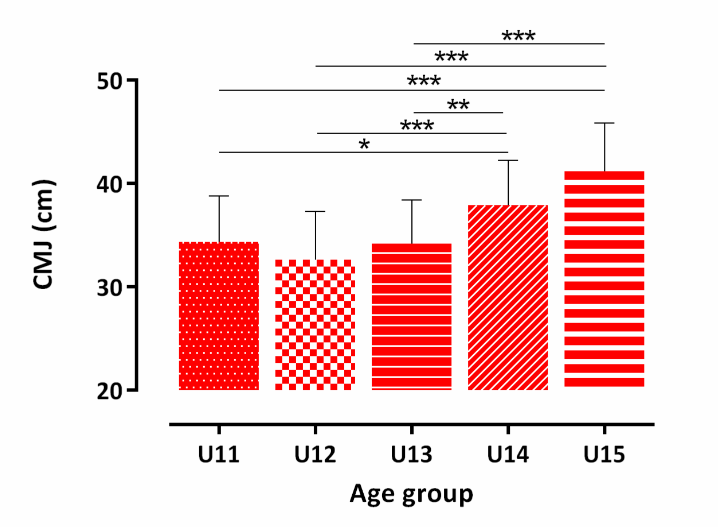


Figure 4.1.34. Differences in the CMJ test between the age groups.
Error bars represent standard deviation.
***p < 0.001; **p < 0.01; *p < 0.05

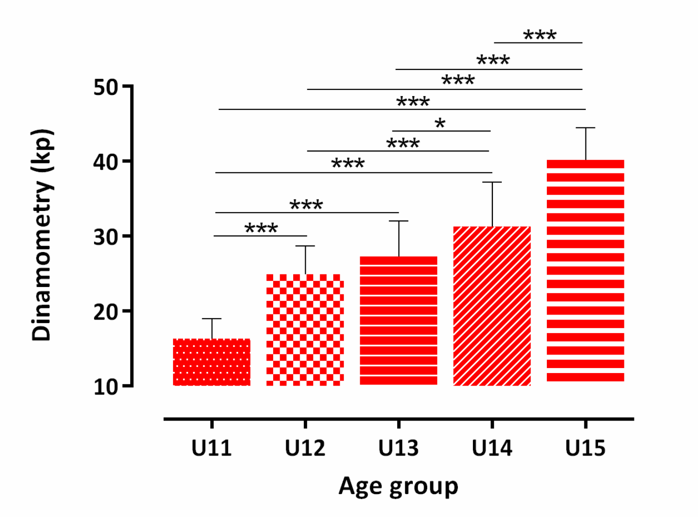


Figure 4.1.35. Differences in hand dynamometry between the age groups.
Error bars represent standard deviation.
***p < 0.001; *p < 0.05

Maturation

APHV and maturity offset

APHV and maturity offset results are shown in Table 4.1.8. A significant main effect for age was found in both variables (p< 0.001). On the one hand, as age increased an increment of APHV was observed (Figure 4.1.36). Nevertheless, there was a small decrement of the age in the U15 group. Overall, the U11 group was the one with the smallest APHV. On the other hand, regarding maturity offset (Figure 4.1.37), the opposite effect was observed. As age increased, years left for the maturity offset decrease significantly.

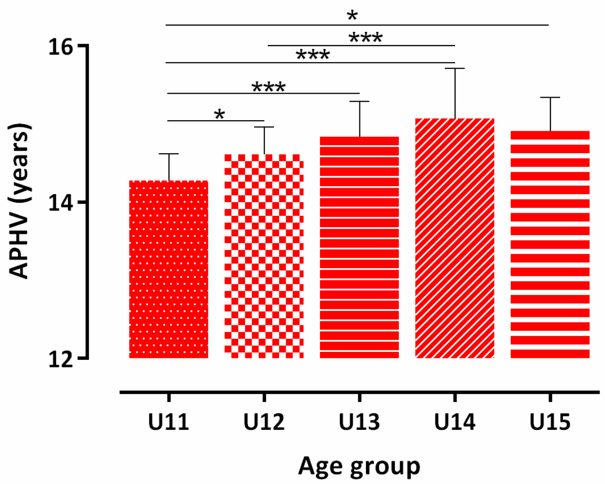


Figure 4.1.36. Differences in APHV between the age groups.
Error bars represent standard deviation.
***p < 0.001; *p < 0.05

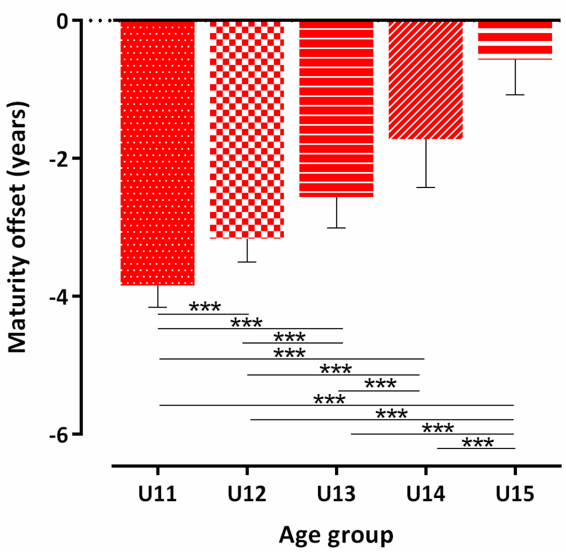


Figure 4.1.37. Differences in maturity offset between the age groups.
Error bars represent standard deviation.
***p < 0.001

Salivary hormones concentration

Salivary hormone concentration results are shown in Table 4.1.8. A significant main effect for age was found in all the variables. In this way, there was a significant increase with age in testosterone and DHEA hormones concentration. As it is shown in Figure 4.1.38, testosterone levels were lower in the U11 and U12 groups. Besides, there was an important increase of testosterone concentration in the U13 age group that continued as age increased. Thus, the U15 group had the higher levels of testosterone. Regarding DHEA (Figure 4.1.39), hormone levels increased with age but significant differences were not appreciable until U14 age group, when an important increase in concentration happened. Thereby, U14 and U15 age group players had higher DHEA and testosterone concentrations compared to the rest of the groups.

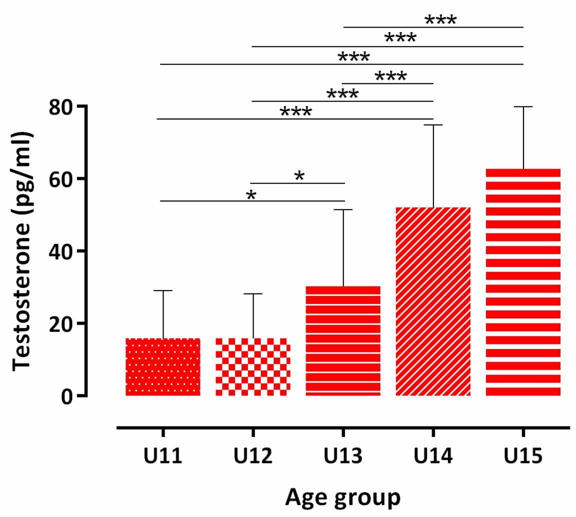


Figure 4.1.38. Differences in salivary testosterone concentration between the age groups.
Error bars represent standard deviation.
***p < 0.001; *p < 0.05

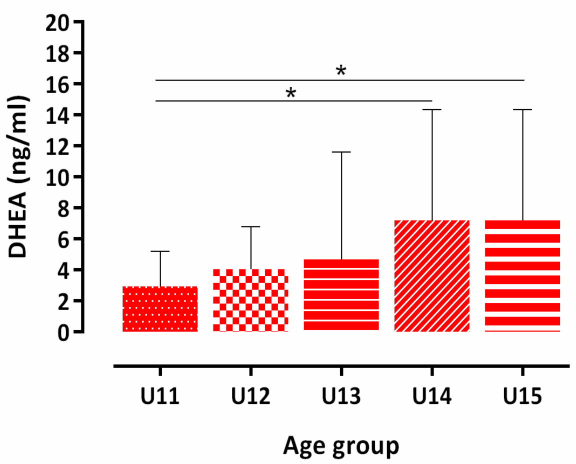


Figure 4.1.39. Differences in salivary DHEA concentration between the age groups.
Error bars represent standard deviation.
*p < 0.05

Table 4.1.8. Maturity related variables of all the players within each age group at the start of the season (mean ± SD).

	N	Under-11	N	Under-12	N	Under-13	N	Under-14	N	Under-15	ANOVA
APHV (years)	25	14.28 ± 0.34	53	14.61 ± 0.35	38	14.84 ± 0.45	32	15.07 ± 0.64	10	14.91 ± 0.43	$F_{4,\ 153}$= 12.47, p<0.001, η^2 = 0.24
Maturity offset (years)	25	-3.84 ± 0.32	53	-3.16 ± 0.34	38	-2.56 ± 0.45	32	-1.72 ± 0.70	10	-0.57 ± 0.51	$F_{4,\ 153}$= 139.01, p<0.001, η^2 =0.78
Testosterone (pg/ml)	25	15.88 ± 13.25	49	15.96 ± 12.26	32	30.37 ± 21.15	25	52.09 ± 22.85	10	62.77 ± 17.09	$F_{4,\ 136}$= 41.18, p<0.001, η^2 = 0.55
DHEA (ng/ml)	27	2.93 ± 2.28	49	4.07 ± 2.73	34	4.68 ± 6.93	25	7.22 ± 7.14	10	8.09 ± 3.29	$F_{4,\ 140}$= 3.09, p<0.05, η^2 = 0.08

APHV: age at peak height velocity; DHEA: dehidroepiandrosterone.

4.3.1.2. Inter-relationships between growth and maturation indicators and physical performance

The effects of growth and maturation indicators (CA, APHV and salivary hormones concentration) on physical performance were examined by Pearson's or Spearman´s product moment correlation coefficient (*r*) (Table 4.1.9 and Figure 4.1.40). Also, a partial correlation controlling age was implemented. Although many correlations are recognized in this study, not all are highly significant relationships. Thus, to determine correlations between variables *r* was interpreted as low (< 0.40), moderate (≥ 0.40 and < 0.80) and high (≥ 0.80) (Evans, 1996).

The correlation matrix of variables is reported in Table 4.1.9. As expected, CA correlated moderately with some of the maturation indicators: APHV and testosterone (p< 0.001; r= 0.62 and p< 0.001; r= 0.74, respectively). Similarly, statistical analysis revealed a positive relationship between CA and physical performance variables. Thus, CA was moderately correlated with velocity 15-m (p< 0.001; r= 0.74), agility (r= 0.68; p< 0.001), Yo-YoIR1 (r= 0.68; p< 0.001), and dynamometry (r= 0.77; p< 0.001). As well, a low correlation was observed with CMJ (r= 0.46; p< 0.001).

Examination of Pearson and Spearman correlation coefficients indicated significant low positive correlations between APHV and testosterone (r= 0.23; p< 0.01), APHV and DHEA (r= 0.17; p< 0.05) and testosterone and DHEA (r= 0.38; p< 0.001). In addition, significant correlations were found between APHV and physical performance variables. Thereby, low correlations were observed with velocity 15-m (r= 0.37; p< 0.001), Yo-Yo IR1 (r= 0.26; p< 0.01), CMJ (r= 0.18; p< 0.05) and dynamometry (r= 0.21; p< 0.01).

Regarding salivary hormones concentration, testosterone was moderately correlated with velocity 15-m ($r = 0.55$; $p < 0.001$), agility ($r = 0.46$; $p < 0.001$) Yo-Yo IR1 ($r = 0.41$; $p < 0.001$) and dynamometry ($r = 0.52$; $p < 0.001$) whilst a low correlation with CMJ was observed ($r = 0.30$; $p < 0.01$). In general, observed relationships were lower between DHEA and physical performance variables when compared to testosterone correlations. Thus, all the physical performance variables except for CMJ correlated little with DHEA ($r = 0.22 - 0.28$; $p < 0.05 - 0.01$).

Results also revealed moderate positive correlations between all the physical performance variables. However, the highest correlations were found between velocity 15-m and the rest of the variables: agility ($r = 0.64$; $p < 0.001$), Yo-Yo IR1 ($r = 0.56$; $p < 0.001$), CMJ ($r = 0.75$; $p < 0.001$) and dynamometry ($r = 0.63$; $p < 0.001$).

A partial correlation was implemented to control the effect of age in the correlation matrix (Table 4.1.10). Thus, results reflect that, when age was controlled, most of the correlations disappeared. By this means, the only relationship between maturation variables appeared to be a negative low correlation between APHV and dynamometry ($r = -0.34$; $p < 0.01$). Similarly, when analyzing physical performance variables, correlations tended to disappear. Yet, significant positive correlations were observed between velocity 15-m and agility ($r = 0.31$; $p < 0.01$), velocity 15-m and CMJ ($r = 0.69$; $p < 0.001$) and Yo-Yo IR1 and dynamometry ($r = 0.34$; $p < 0.01$).

Table 4.1.9. Inter-relationships between selected variables in participants.

	CA	APHV	Testosterone	DHEA	Velocity 15-m	Agility	Yo-Yo IR1	CMJ	Dynamometry
CA									
APHV	**.510*****								
Testosterone	**.622*****	.230**							
DHEA	.281**	.172*	.388***						
Velocity 15-m	**.749*****	.373***	**.551*****	.225*					
Agility	**.689*****	.520***	.468***	.248**	**.644*****				
Yo-Yo IR1	**.681*****	.266**	.461***	.269**	**.564*****	**.567*****			
CMJ	.460***	.180*	.301**	.060	**.753*****	.428***	.366***		
Dynamometry	**.774*****	.217**	**.528*****	.282**	**.634*****	.604***	.693***	.412***	

CA: chronological age; APHV: age at peak height velocity; DHEA: dehidroepiandrosterone; Agility: barrow agility test; Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump: Dynamometry: hand dynamometry.

$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

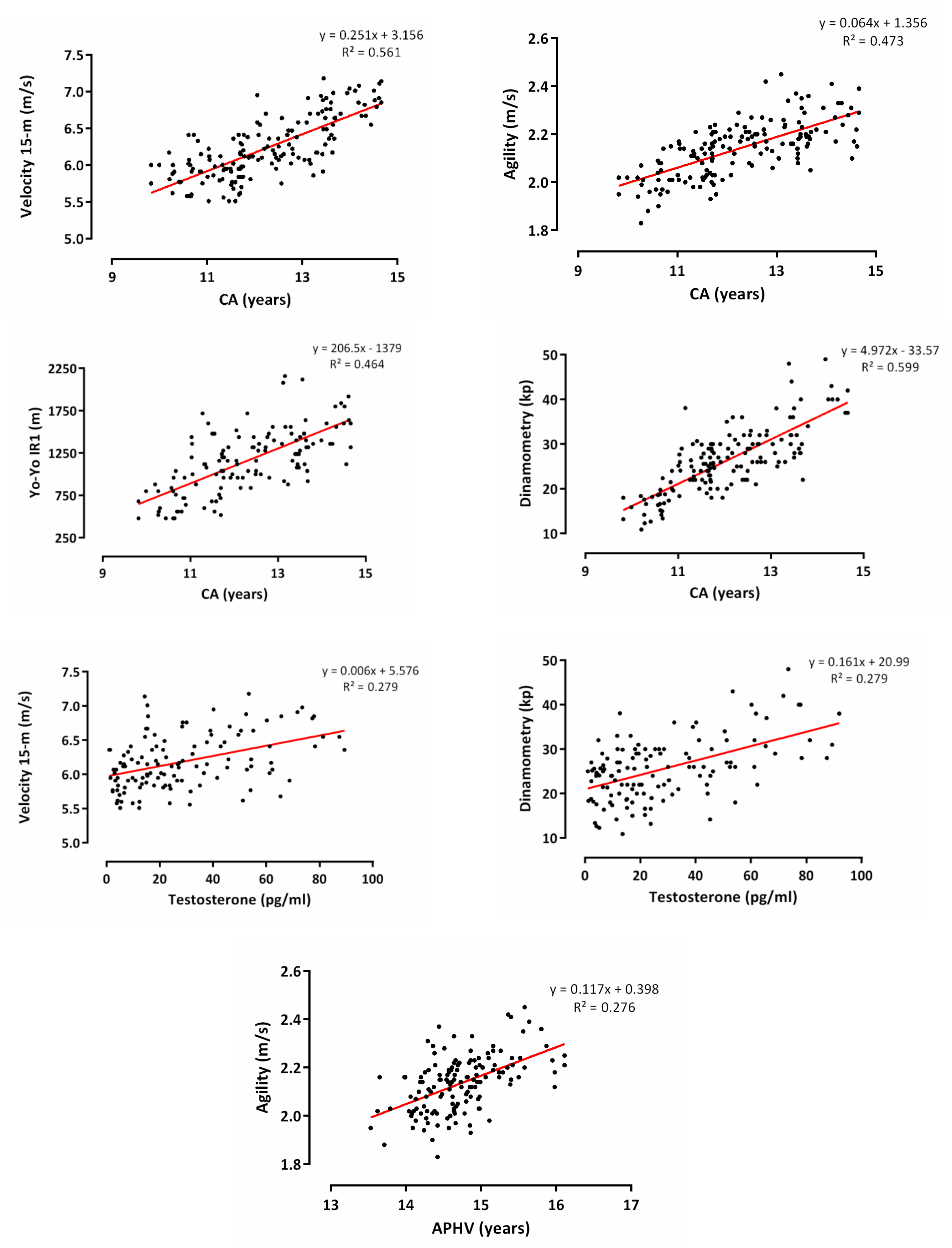


Figure 4.1.40. Pairs of selected variables in which the explanatory power was more than 50%.

Table 4.1.10. Inter-relationships between selected variables in participants controlling for chronological age.

	APHV	Testosterone	DHEA	Velocity 15-m	Agility	Yo-Yo IR1	CMJ	Dynamometry
APHV								
Testosterone	-.163							
DHEA	-.008	.229						
Velocity 15-m	-.134	.093	-.082					
Agility	-.058	.078	-.036	**.316****				
Yo-Yo IR1	-.207	.001	.048	.057	.205			
CMJ	-.066	.013	-.140	**.697*****	.150	.182		
Dynamometry	**-.345****	-.051	.063	.216	.190	**.342****	.205	

APHV: age at peak height velocity; DHEA: dehidroepiandrosterone; Agility: barrow agility test; Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump; Dynamometry: hand dynamometry.
**p< 0.01; ***p< 0.001.

4.1.4. Discussion

Although the study populations in the literature related to youth soccer players are very often drawn from adolescent elite soccer players, a very interesting aspect of the current study is that measurements were taken in a large group of highly selected pre-adolescent soccer players. Indeed, the sample spans the transition from late childhood or pre-puberty, the early adolescent or early-pubertal years, the interval of maximal growth in height and the mid-pubertal years. Consequently, as clubs are increasingly interested in the talent identification programs, these results may be of use for the coaches and the staff as a template for the selection of future professional players within the club but also for comparison with other young players of the same level.

4.1.4.1 Age related differences in anthropometry

As children grow, they become taller and heavier, the amount of lean and fat tissue increases, their organs increase in size, and so on (Baxter-Jones et al., 2005). Whereas the general pattern of postnatal growth is quite similar from one individual to another, there is a considerable individual variability in growth when adolescence occurs (Malina, Bouchard, & Bar-Or, 2004). One of the hallmarks of puberty is the adolescent growth spurt. It is well known that rates of growth differ for stature and body mass and that the growth spurt occurs, on average, first in stature and then in weight. Moreover, the variation in the timing and tempo of the adolescent growth spurt somewhat alters the trend (Beunen & Malina, 1988).

In the present study, we observed that players aged 11 were smaller regarding height when compared to the rest of the age groups. Nevertheless, while differences in body mass were not especially pronounced between the younger age groups (U11-U12-U13), the U14 and U15 age groups appeared to be significantly heavier than the rest (Figure 4.1.2). Consequently, BMI values were also higher in the U14 and the U15 age groups when compared to the other groups.

On the whole, heights and body masses of the sample compared favorably with other samples of youth soccer players in Portugal and Europe (Malina, Bouchard, & Bar-Or, 2004; Malina, Eisennman, et al., 2004) and ranged around the age-specific 75th and 50th percentiles of Basque reference data in height and body mass, respectively (Hernandez et al., 1988). As a result, mean BMIs were slightly below age-specific reference medians. This is consistent with the notion that young male athletes tend to be taller than average and, therefore, tend to have less weight-for-height (Malina et al., 2011). It the literature it has been observed that peak weight velocity appears to occur somewhat closer to age at height velocity in boys. Moreover, reported PHV in North African and European boys vary between 13.3 and 14.4 years (Malina, Bouchard, & Bar-Or, 2004). Thus, it seems logical to suggest that in our sample a height and body mass spurt may have occurred in players aged 13-14 as, from that point on; as age increased the differences become more significant.

In agreement with studies performed with young soccer players (Gil et al., 2010) we found that circumferences were significantly larger in the U14 and the U15 groups while diameters were significantly smaller in the U11 group compared to the U13, U14 and U15 groups. This is in line with trends of growth observed in the general population were growth of fat and lean tissues on the extremities occurs during the adolescent growth spurt and, therefore, circumferences get larger. Also, maximal gains in humerus and tibia widths occur just before PHV (Malina, Bouchard, & Bar-Or, 2004). Correspondingly, in a study carried with non-elite soccer players aged 14 to 17 years old, Gil, Ruiz, et al. (2007) indicated that from age 16 onwards the progression of growth decreases, suggesting that soccer players have reached the height, body mass, circumferences and diameters of adult soccer players. In the current sample a linear growth of height, body mass, circumferences and diameters was observed as age increased. Thus, results suggest that boys aged 14-15 years old have not finished their growth process yet.

The amount of fat has been previously included among the predictors of performance in youth soccer players (Figueiredo, Coelho e Silva, & Malina, 2011; Gil et al., 2014). With regard to the sum of skinfolds, it is well known that trunk skinfolds increase to about 13 years of age, decline slightly through 14 years of age and then increase in thickness through late adolescence (Malina, Bouchard, & Bar-Or, 2004). Even if the differences between age groups were not significant in our study, whereas a slight decrease in subescapular, suprailiacal and abdominal skinfold thicknesses was observed in the U13 and the U14 age groups, results tend to rise again in the U15 age group. Other studies have already shown that while trunk fat increases from puberty until adulthood, during puberty the fat of the extremities decreases (Gil et al., 2010; Malina, Bouchard, & Bar-Or, 2004). Specifically, the current data indicated a decrement in fat in the ∑ extremities skinfold with age, particularly in the lower limbs. Therefore, although the calculation of the ∑ skinfolds showed an overall decrease with age, it is worth noting that whilst there was a decline in the ∑ extremities skinfolds, ∑ trunk skinfolds tend to rise in the older groups. Moreover, the decline in the ∑ extremities skinfolds thickness was greater than that for the ∑ skinfolds.

When body composition was analyzed, it was found that the average fat percentages of the overall sample were appropriate for their level and age, which is around 10-12 % (Gil et al., 2010; Nikolaidis & Vassilios Karydis, 2011; Shepard, 1999). Previous analysis in body composition in the general population has shown that changes in total body fat expressed as a percentage of body mass increases gradually in males until just before the adolescent growth spurt (about 11-12 years) and then gradually declines. Indeed, fat percentage reaches its lowest point at about 16 to 17 years of age in males and then gradually rises into young adulthood (Malina, Bouchard, & Bar-Or, 2004). Contrasting with this affirmation, significant differences were not observed in fat percentage among the age groups, certainly due to the fact that the present sample is beyond the expected age when gradual rise is expected (16-17 years old) (Rogol et al., 2002).

However, the U14 and the U15 groups appeared to have significantly more fat mass that their younger peers. This could be explained by the fact that fat mass increases through adolescence but appears to reach a plateau or to change only slightly near the time of the adolescent growth spurt in boys (about 13-15 years) (Malina, Bouchard, & Bar-Or, 2004).

Regarding the somatotype, the major component of the sample was mesomorphy. Indeed, mesomorphy has been previously defined as the major component in elite players (Gil et al, 2010; Mirkov, Kukolj, Ugarkovic, Koprivica, & Jaric, 2010; Rienzi et al., 2000). Although somatotype components changed slightly across de age groups, differences were not significant. However, it is worth noting that, unlike other studies that had reported a higher endomorphy component in children groups compared to adult groups (Nikolaidis & Vassilios Karydis, 2011), in the present sample the U11 group was ecto-mesomorphic while the rest of the age groups tend to be mesomorph. This finding indicates that the current sample of players is leaner than similar samples of youth soccer players (Le Gall et al., 2010). Interestingly, as the sample is highly selected, this is consistent with idea that lower fat percentages correlates with better physical performance (Nikolaidis, 2012a) and, therefore, the young players selected to play in the club tend to be leaner.

4.1.4.2. Age related differences in physical performance

Physical fitness testing can be an effective procedure to reveal complete and suitable information of soccer player's physical and physiological capacity. Consequently, field tests seem to be useful to provide specific and useful information about the performance to coaches because of their simplicity and lack of equipment (Chamari et al., 2008; Mirkov, Nedeljkovic, Milanovic, & Jaric, 2004). Nevertheless, information on attained levels of performance is not as extensive for pre-adolescence as it is for adolescence. Thus, the data we analyzed was expected to reveal changes in physical performance in the young elite soccer players across different age groups.

The findings of the present study agree with those of previous authors (Le Gall et al., 2010; Mirkov et al., 2010) in that performance characteristics vary according to player's age. Indeed, a positive correlation was observed between age and performance. These findings confirmed previous research that suggested that the large correlation between age and some physical performance indicators may be associated with the development of the central nervous system (Viru et al., 1999). Additionally, when age was controlled, most of the correlations observed disappeared reinforcing the idea that performance is aligned to chronological age rather than to maturity at these ages. However, maturational factors such as increased muscle mass are also likely to influence the development (Williams, Oliver, & Faulkner, 2011).

Regarding velocity (15-m test), the analysis revealed a significant improvement of performance with increasing age. Moreover, a moderate correlation was observed between CA and velocity 15-m ($r = 0.749$). Results revealed that players in the two youngest age groups recorded similar results (5.91 ± 0.25 m/s and 5.94 ± 0.24 m/s, respectively). These velocities were significantly lower when compared with the rest of the age groups. Although comparisons to previous sprint data are difficult given that in most of the studies the most common sprint test used is the 30-m sprint (Deprez et al., 2013; Gravina et al., 2008; Lago-Peñas, Rey, Casáis, & Gómez-López, 2014; Malina, Eisennman et al., 2004; Wong, Chamari, & Wisløff, 2010;), differences between age groups were also observed by Williams et al. (2011) in the 30-m sprint test, reporting significantly slower velocities in the U12 category when compared with U13 to U16 categories. Similarly, the observed findings may be supported by previous studies that state that strength increases linearly with age until 13 to 14 years of age in boys, when there is acceleration in strength development (Malina, Bouchard, & Bar-Or, 2004). Altogether, these findings may provide some support for the concept of a period of optimal trainability of the speed which has been suggested to occur between the ages of 13 - 15/16 years in boys (Viru et al., 1998; Williams et al., 2011).

We believe that, the significant differences observed in the sprinting test from the U13 age group onwards may be due to the maturation process that occurs during puberty. Accordingly, a moderate positive correlation was observed between testosterone and velocity 15-m that disappeared when age was controlled (r= 0.551) supporting previous studies (Moreira et al., 2013) and reinforcing the idea that changes in sprint performance around this age are linked to chronologically associated development of the central nervous system (Williams et al., 2011).

On the average, it has been reported that performance in the vertical jump increases linearly with age until 18 in boys (Malina, Bouchard, & Bar-Or, 2004). Moreover, the moderate significant correlation (r= 0.460) observed between CMJ and chronological age supports previous findings that suggest that age is a very important factor in CMJ (Huijgen, Elferink-Gemser, Post, & Visscher, 2009; Nikolaidis, Ziv, Lidor, & Arnon, 2014; Philippaerts et al., 2006; Williams et al., 2011). Whereas significant differences were found between the U14 and the U15 age groups and the rest of the groups, statistical differences were not detected between the youngest groups. Furthermore, a slight decrement in performance was observed in the U12 age group. On the one hand, it has been reported that during the period between 13 and 14 years the most growth of boys in stature, body mass, arm span, and sitting height took place (Malina, Eisennman, et al., 2004). Hence, the improvement observed in the in the eldest age groups may be related to increases in body size during this period. On the other hand, the temporary decline in performance could be attributed to the "*adolescent awkwardness*", disrupting motor coordination during periods of accelerated physical growth (Philippaerts et al., 2006).

Even if a lack of differences in the youngest ages could be particularly surprising, similar results have been observed with smaller statistical differences between the U10 and the U12 categories and the largest difference between the U14 and the U16 categories (Nikolaidis et al., 2014). Nevertheless, comparisons to previous jump data merits caution. While our results were higher than those observed in the U12 and the U14 categories of a youth soccer academy (Nikolaidis, 2014), they appeared to be lower than those observed in players (U12 to U16) from an English Football League academy (Williams et al., 2011). We believe that the aforementioned differences may be partly a consequence of a need of standardization in jump protocols and measurement equipment.

Agility is a result of a number of neurophysiological factors and it is difficult to determine exactly which factors contribute to a changed result on a test (Buttifant, Graham, & Cross, 2002). In the current analysis, the statistical analysis confirmed a moderate correlation between agility and age (r= 0.689). However, when age was controlled a moderate correlation was found between agility and APHV. Previously, Wilmore and Costill (1994) suggested that high levels of skill are impossible if the child has not reached neural maturity and, similarly, Beneke, Hütler and Leithäuser (2007) reported that short-term maximal performance tends to be lower in children than adolescents and adults due to limitations of glycolysis. Hence, it seems logical to conclude that maturation influences agility in some extent. These observations are in line with the results of the present study where the observed values of the U11 age group were significantly lower when compared with their older peers. However, caution is necessary when interpreting the present data. Indeed, it seems logical to believe that as older players had been more years training in the club, previous experience with the protocol procedure may have contributed to higher velocity values. Thus, it is important to note that potentially confounding factors in explaining the determinants of agility performance in adolescent soccer players may include chronological age, the maturity-related variation, and the previous training experience of the youth soccer players.

The Yo-Yo Intermittent Recovery tests (Level 1) have rapidly become some of the most extensively studied fitness tests in sports science to assess players ´abilities to repeatedly perform high-intensity exercise (Bangsbo et al., 2008). Indeed, the protocol has been showed to be a reliable and valid measure of fitness performance in soccer (Krustrup et al., 2003), and a useful tool also used by coaches and researchers with youth (Castagna, Impellizzeri, Cecchini, Rampinini, & Alvarez, 2009; Deprez, Vaeyens, Coutts, Lenoir, & Philippaerts, 2012; Hammami et al., 2013).

The substantial improvement of the test with increasing age and the moderate correlation observed between chronological age and Yo-Yo IR1 (r= 0.681) confirms previous observations (Deprez et al., 2012; Krustrup et al., 2006). When analyzing the data more closely, two significant and more marked improvement peaks were observed. Firstly, a marked increase happened between the U11 and the U12 age groups. For the better understanding of this result, it is worth noting that players entered the club at 10-11 years of age. Consequently, for the first time, the U11 players received further specific and systematic soccer training. Previous authors had reported that the development of intermittent endurance run appears to be positively influenced by systematic training exposure (Bangsbo et al., 2008). Thus, we believe that the aforementioned difference between the U11 and the U12 age groups may be partly a consequence of the exposure to more specific preparation. Secondly, another marked improvement was observed between the U13 and the U14 age groups. Previous research has shown that the age-related development of aerobic mechanisms during adolescence is related to the increases in body dimensions and muscle mass and need to be considered in the context of changes associated with growth and maturation (Armstrong, Welsman, Nevill, & Kirby, 1999; Beunen et al., 2002; Geithner et al., 2004). Thus, our data suggests that the main change between U13 and U14 may be due to maximal rate of growth and is in agreement with previous authors (Mujika, Spencer, Santisteban, Goiriena, & Bishop, 2009; Philippaerts et al., 2006; Vaeyens et al., 2006).

The average Yo-Yo IR1 values appear to be higher in the present sample in comparison with corresponding age values reported in some studies (Castagna et al., 2009; Rampinini et al., 2010). For example, the U15 age group in this study had a considerably greater performance score (1602 ± 299 m) than that of age-matched Croatian youth soccer players (1.184 ± 345 m) (Markovic & Mikulic, 2011). These comparisons show the high level of intermittent-endurance performance of the tested Basque youth elite players. Noteworthy, our data reflects a large variability in the tests results within the age groups. We believe that the differences in the performance of the Yo-Yo IR1 test in the present sample may be to some extent related to the position of each player in the team.

Grip strength or handgrip strength is commonly used to evaluate muscular fitness in school physical education. Consequently, data for the general population of adolescent males suggested that linear increases in handgrip occur up to age 13-14 years old after which the development accelerates in boys (Cohen et al., 2010). Similar results were obtained in the present sample where significant improvements were observed as age increased and a moderate correlation was found between chronological age and handgrip (r= 0.774). Noteworthy, results also indicated a moderate positive correlation between testosterone and handgrip (r= 0.528). Other authors have also reported that strength development is closely related to chronological age and hormonal maturity as muscle size during growth is mainly determined by the hormonal environment (Hansen et al., 1999). However, when age was statistically controlled, these relationships appear and a low correlation remained between handgrip and APHV (r= - 0.345). These results are in agreement with those observed in youth soccer players by Philippaerts et al. (2006).

In the aforementioned study, authors concluded that peak gains in handgrip were coincident with peak height velocity and were probably related to the adolescent spurt in muscle mass that occurs shortly after peak height velocity. Also, another explanation for this finding may be related to player's height. It is important to remember that the maturity offset protocol used in the present study is supported in an equation based in measurements of height, sitting height, body mass and chronological age (Mirwald et al., 2002). Thus, it is reasonable to think that, as in the tests used in the present study (hand dynamometry) players had to squeeze a dynamometer with their hand; presumably higher players with larger hands score better in the test.

The handgrip strength results observed were similar to those observed in the general population in a study performed with 3773 English boys were handgrip strength of the dominant hand was 19.6 kg, 22.6 kg, 27.2 kg, 32.5 kg and 39 kg for the 11, 12, 13, 14 and 15 year old boys, respectively (Cohen et al., 2010). Nevertheless, our results appeared to be lower than the reference data in soccer (Canhadas, Silva, Chaves, & Portes, 2010; Nikolaidis, 2012a). Although handgrip could be measured using inexpensive, portable and easy-to-use dynamometers that have shown to be reliable and valid (Cohen et al., 2010), caution should be exercised when interpreting the results because of the lack of relevant developmental norms for the grip strength in children (Häger-Ross & Rösblad, 2002).

4.1.4.3. Age related differences in maturation

Growth maturation and development occur simultaneously and interact during approximately the first two decades of children's life (Malina, Bouchard, & Bar-Or, 2004). Specifically, maturation refers to progress toward the biologically mature state or biological maturity and, therefore, maturation is a process while maturity is a state (Malina, 2014). Maturity associated differences in body size are apparent at 6 or 7 years of age, increase with age, and are greatest during adolescence due to individual differences in the timing and tempo of the adolescent growth spurt (Malina, Cumming, Kontos, et al., 2005).

This point of view is necessary since chronological age may not correspond to biological age and, consequently a high inter individual variability of certain parameters could be found within the same class of athletes selected for chronological age (Baldari eta al., 2009). In our study, as expected, a significant main effect for age was found in the results of the maturity indicators.

Regarding the growth spurt, age at peak height velocity and peak height velocity are the most commonly reported parameters and have been previously used with youth soccer players (Malina, Einsennman, et al., 2004; Philippaerts et al., 2006). When comparing the results, we observed that the mean age at peak height velocity for the U13 age group of the present study (14.84 ± 0.45 years) was somewhat later than estimates for the sample of the Ghent Youth Soccer Project (13.8 ± 0.8 years; Philippaerts et al., 2006) and the range of estimated ages at peak height velocity for samples of European boys (13.8 - 14.2 years; Malina, Bouchard, & Bar-Or, 2004). The estimated age at peak height velocity is probably later in our study due to the large differences observed between individuals. Indeed, some of the players appeared to be late maturers while some of the others were considered early maturers. Thus, some of the earliest may have already attained peak height velocity before or during the study. In fact, this should also explain the small decrement observed in the age at peak height velocity in the U15 age group.

More recently, other indicators of maturity status have been introduced in studies of young athletes: endocrine hormone concentrations. During adolescence many adrenal hormones are involved in the maturational process (Rogol et al., 2002). Moreover, the timing of the adolescent spurt, associated with genital and pubic hair development is in line with the assumption that androgens play a key role in growth (Moreira et al., 2013). Hence, both hormones studied in the present investigation are androgens; while testosterone is the primary steroid hormone within the androgen family, DHEA is one of the major steroid hormones secreted from the adrenal glands, which serves as a precursor of other steroid hormones including testosterone (Papacosta & Nassis, 2011).

In regard to monitoring endocrine hormones, in the present study saliva samples were used because salivary hormone measurement in human studies provides a practical and noninvasive alternative since it can be collected rapidly, frequently and without stress and requires less medical training (Granger et al., 2007; Netherthon et al., 2004).

The data obtained in the current study revealed a significant main effect for age in both hormones confirming that testosterone and DHEA levels continue to increase with age and supporting previous findings that suggest that age may be a important factor in determining levels of testosterone (Di Luigi et al., 2006; Durdiaková, Fábryová, Koborová, Ostatníková, & Celec, 2013) and DHEA (Netherthon et al., 2004). Nevertheless, a great variability was observed in both hormones concentrations among all the age groups. In line with this, previous findings have already shown that the range of individual differences in hormone levels is large and, within the same age and sex, some individuals are more than twice as high as others (Dabbs, 1990b). Therefore, comparisons to previous data merit caution. Certainly, discrepancy with previous findings (Di Luigi et al., 2006; Moreira et al., 2013) may be likely related to individual differences among the subjects and diverse saliva collection methodologies.

Finally, it is interesting to note that, in the youngest age groups results were similar in both indicators. Moreover, it seems that between the U13 and the U14 age groups a spurt in hormones concentration happened. This data supports previous findings that reported that during adolescence the endocrine system is subject to major alterations (Baldari et al., 2009; Moreira et al., 2013).

4.1.5. Conclusion

The present cross-sectional study provides useful and comprehensible data for coaching staff regarding the expected anthropometric, performance and maturation characteristics of highly selected youth soccer players in different age categories. Moreover, results revealed improvements in performance with increasing age in all the analyzed physical fitness indicators. However, the present cross-sectional data highlights the need to consider growth and maturity associated variation in performance. As such, the patterns of physical growth and maturation of young soccer players merit more detailed consideration.

CHAPTER 2

ANTHROPOMETRICAL CHARACTERISTICS AND SOMATOTYPE OF ATHLETIC CLUB PLAYERS AND THEIR COMPARISON WITH THE GENERAL POPULATION, SOCCER PLAYERS OF LOCAL TEAMS AND *DENA* TALENT IDENTIFICATION PROJECT PLAYERS

4.2. CHAPTER 2

4.2.1. Introduction

Several studies have observed that youth soccer players classified in different playing levels differ in body size, maturity, strength, flexibility and soccer specific skills (Figueiredo et al., 2009; Le Gall et al., 2010; Malina, Ribeiro, Aroso, & Cumming, 2007). Those studies had compared elite and sub-elite young soccer players, elite and non-elite players (Castagna et al., 2006; Cometti et al., 2001; Hansen et al., 1999; Vaeyens et al., 2006) and not only that, but also comparisons between non-professional soccer players and the general population have been performed before (Gil, Ruiz, et al., 2007).

Shortly, it has been shown that elite players tend to be taller, bigger and have a higher level of fitness and greater technical ability than sub-elite and non-elite soccer players (Castagna et al., 2006; Le Gall et al., 2010; Malina, Ribeiro, et al., 2007). Likewise, when comparing young non-professional soccer players and the general population, it has been observed that soccer players were bigger and taller and had larger diameters (Gil et al., 2010; Malina et al., 2000). Moreover, soccer players present less amount of body fat and were more mesomorph than the general population, who tended to be more endomorph.

It seems clear that the purpose of most of these studies was to describe structural and functional characteristics of elite soccer players, and to make comparisons to find a relationship between results and playing level. In fact, understanding the profile of successful players could give coaches, trainers, and exercise scientists better knowledge of this particular group of athletes and may serve as template for comparison with other young players of the same level.

Nevertheless, most of the above mentioned studies have been based in adolescent or adult population of different playing levels but there is little research about pre-adolescent soccer players. Furthermore, most of the studies have been performed in a narrow age range or category; but studies considering a bigger age range are scarce. Considering that comparing results in players of the same level is not an easy task due to the differences between the diverse age groups, knowledge of the differences of playing levels across different age ranges could give important information to coaches and technical staff in youth academies.

To the knowledge of the author, there are no preceding studies comparing elite soccer players, sub-elite soccer players and amateur soccer players and general population at pre-adolescent ages. Thereby, the aim of the present study was to describe the anthropometric differences between elite, sub-elite, non-elite soccer players and the general population of pre-adolescent subjects in four different age groups.

4.2.2. Methodology

Study design

In this chapter, the data used for the statistical analysis was taken from two different sources. On the one hand, to analyze the characteristics of the players of the Athletic Club, data from the results obtained in the previous chapter of this dissertation was employed (see: Chapter 1). On the other hand, data from the General Population, players of Local Teams and *DENA* players was taken from a previous thesis dissertation performed by Jaime Zubero (See: Zubero, 2010).

In both studies, measurements taken for the analysis were performed near the start of the competitive season. Anthropometric measurements in each study were taken by an experienced observer following the guidelines outlined by the International Society for the Advancement of Kinanthropometry (Stewart et al., 2011). The same equipments and methodological procedures were adopted by the anthropometrists for all the measurements: players only wore shorts and testing took place at the same time of the day and the same external conditions. The following measurements were taken: height, body mass, sitting height, 6 skinfolds (tricipital, subescapular, abdominal, suprailiacal, thigh and leg), 4 circumferences (relaxed arm, flexed arm, thigh and leg) and 4 perimeters (wrist, elbow, knee and ankle). Body composition and somatotype were calculated.

Despite many benefits of direct anthropometry, including its quickness and low cost and also lack of need for sophisticated equipment, this method has some inherent limitations such as the need to train anthropometrists and high error between the measurements (Hashemi-Nejad, Choobineh, Reza Baneshi, & Roodbandi, 2013; Ulijaszek & Kerr, 1999). Thus, in order to evaluate the method of direct anthropometry, the intra-evaluator and the inter-evaluator Inter-Class Correlation Coefficient (ICC) and Technical Error of Measurement (TEM) were calculated.

ICC (Inter-Class Correlation Coefficient) is an index for the evaluation of reliability. ICC is used for identifying the relation between two quantitative variables in one group or class (Table 4.2.1). A value of 0.95 indicates that 95 % of variance in measures is attributed to the real variance among the participants, and the remaining 5 % is related to either the error of measurements of the variance between participants and observers.

Table 4.2.1. Qualitative classification of inter-class correlation (ICC) values as degrees of agreement beyond chance (Peat & Barton, 2005).

ICC values	Degrees of agreement (reliability) beyond chance
0	None
<0<0.2	Slight
0.2<0.4	Fair
0.4<0.6	Moderate
0.6<0.8	Substantial
0.8-1	Almost perfect

Table 4.2.2. Relative Technical error of measurement (TEM) values considered as acceptable. Gore, Norton, & Olds (2000) in Norton & Olds (2000).

Type of analysis		Beginner anthropometrist	Skillfull anthropometrist
Intra-evaluator	Skinfolds	7.5 %	5.0 %
	Other measures	1.5 %	1.0 %
Inter-evaluator	Skinfolds	10.0 %	7.5 %
	Other measures	2.0 %	1.5 %

Although ICC may provide a measure of consistency between two continuous variables, it does not permit clarification of the magnitude by which two measurements differ. Therefore, another method which can be employed is the technical error of measurement (TEM) (Table 4.2.2), which measures the standard deviation between repeat measurements. It is obtained by taking repeat measurement of the same subject by one or more observers (Perini, Oliveira, Ornellas, & Oliveira, 2005) Thus, the TEM allows the calculation of the minimal detectable change.

In order to perform the intra-evaluator calculation, the results of the measurements of 20 volunteers were considered at the first and second evaluation by each anthropometrist (Table 4.2.3). Similarly, to perform the inter-evaluator calculation, the measurements to be considered were performed by the two anthropometrists in the same group of volunteers. For that aim, randomly selected 16 young soccer players within the club were measured (15.41 ± 0.48 years of age).

Table 4.2.3. ICC and TEM for each anthropometrist.

	TEM %			ICC		
	Mean	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**
First anthropometrist Intra-observer	0.34	0.00	1.26	0.99	0.97	1
Second anthropometrist Intra-observer	0.99	0.14	2.87	0.98	0.95	1
Inter-observer	3.29	0.13	7.08	0.94	0.48	1

Sample

Considering all the data collected, a total of 528 players belonging to four different age groups (Under-11 (U11), Under-12 (U12), Under-13 (U13) and Under-14 (U14)) and four different levels (the General Population, Local Teams players, DENA players and Athletic Club players) participated in this study. Specifically, the youngsters of the General population belonged to 4 different schools close to the sport facilities of the Athletic Club in Lezama (Gorondagane, Gandasegi, Eguzkibegi and Askartza schools). Similarly, players in the Local Teams belonged to two local teams located nearby the club (CD Galdakao and CD Ugao). In regard to *DENA* project players, they belonged to different teams within the project *DENA*. In this talent identification project, the Athletic Club selected the best players in the area to create "new" teams integrated in the regional soccer clubs. Finally, players of the Athletic Club were part of the "*alevin"*, "*infantile*" and "*cadet*" categories within the club. The number of players analyzed in each age group and sport level is shown in Table 4.2.4.

Table 4.2.4. Number of players within playing level and age group.

	Under-11	Under-12	Under-13	Under-14	Total
General Population	60	61	15	17	153
Local Teams	13	27	27	25	92
DENA players	44	42	30	22	138
Athletic Club	25	53	37	30	145
Total	142	183	109	94	528

Statistical Analysis

As data from the General Population, players of Local Teams and *DENA* players was taken from a previous dissertation (Zubero, 2010), information for each player was not available. Hence, mean and standard deviations were used to compare the groups. To determine the differences between age groups the magnitude of the differences or effect size (ES) were calculated according to Cohen (1988) and interpreted as small (> 0.2 and < 0.5), moderate (≥ 0.5 and < 0.8) and large (≥ 0.8).

4.2.3. Results

4.2.3.1. Height, body mass and BMI

Regarding height, players of the Athletic Club were significantly taller than the rest of the players across all the age groups (d= 0.30 - 1.18) (Figure 4.2.1). Also, it can be observed that differences were even higher in the U13 and the U14 groups. In this regard, large effect sizes between the players of the Athletic Club and Local Players were identified (d= 1.04 - 1.18), as well as medium effects sizes between the players of the Athletic Club and the General Population and *DENA* players (d= 0.55 - 0.74).

Looking at the body mass in Figure 4.2.2, it may be observed that results fluctuate during age groups. Firstly, in the U11 year old group, Athletic Club players were significantly lighter than those in the General Population and *DENA* players (d= 0.30 - 0.54). Nevertheless, as increasing age, Athletic Club players became heavier than the rest. Secondly, in the U14 group, Athletic Club players were significantly heavier than all the other groups (d= 0.28 - 0.87).

Results in Figure 4.2.3 indicate that Athletic Club´s players had the lowest BMI among all the age groups. In the youngest groups, U11 and U12, differences between the Athletic Club´s players and the General population and the Local Teams were categorized as small to medium (d= 0.28 - 0.70). Similar results were observed in the U13 but differences were even larger (d= 0.50 - 0.84) when comparing Athletic Club´s players with the rest of the groups. Nevertheless, it is interesting to note that BMI differences become lower again in the U14 Athletic Club´s players.

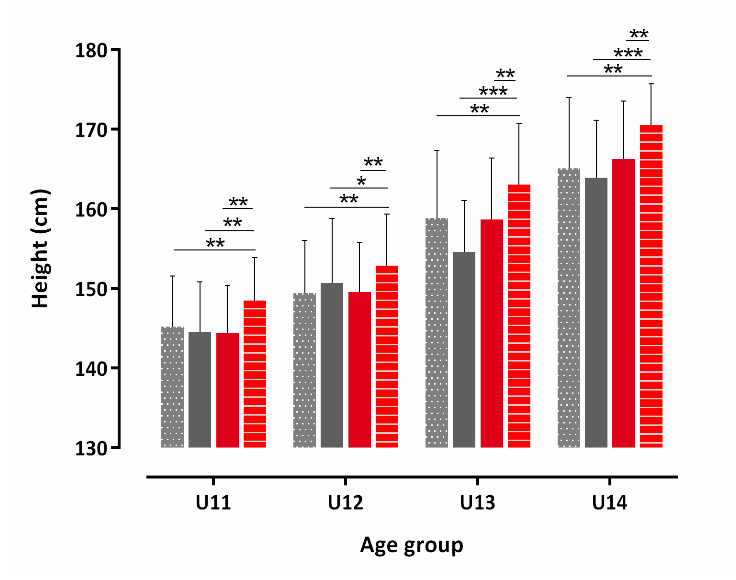


Figure 4.2.1. Differences in height between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size

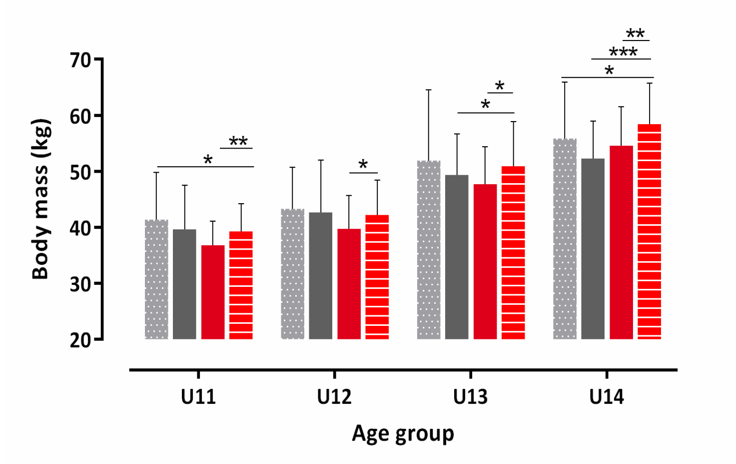


Figure 4.2.2. Differences in body mass between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size

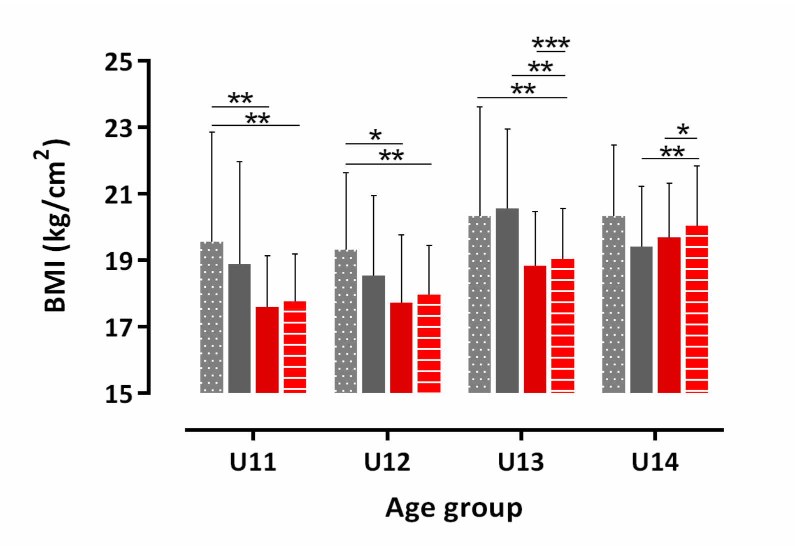
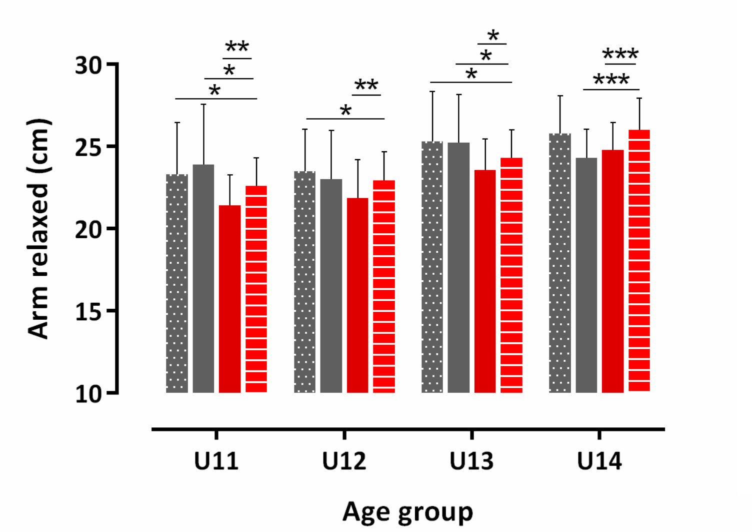


Figure 4.2.3. Differences in BMI between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size

4.2.3.2. Circumferences and diameters

With regard to diameters, most of the diameters were significantly bigger in the Athletic Club´s players in among nearly all the age groups (d= 0.28 - 1.62) (Figures 4.2.4 to 4.2.7). However, the results in circumferences were heterogeneous (Figures 4.2.8 to 5.2.11). On the one hand, the arm relaxed circumference was significantly smaller in the Athletic Club players across all the age groups (d= 0.26 - 0.66) with the exception of the U14 group were the circumference was bigger (d= 0.70 - 0.92). On the other hand, Athletic Club players had the largest arm flexed circumference among all the age groups (d= 0.22 - 1.2). Nevertheless, it is worth mentioning that the Athletic Club players had smaller circumferences in the thigh and the leg among all age groups (d= 0.24 - 0.96).



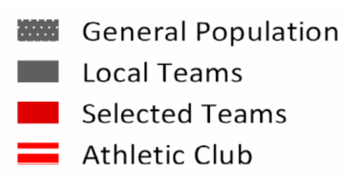
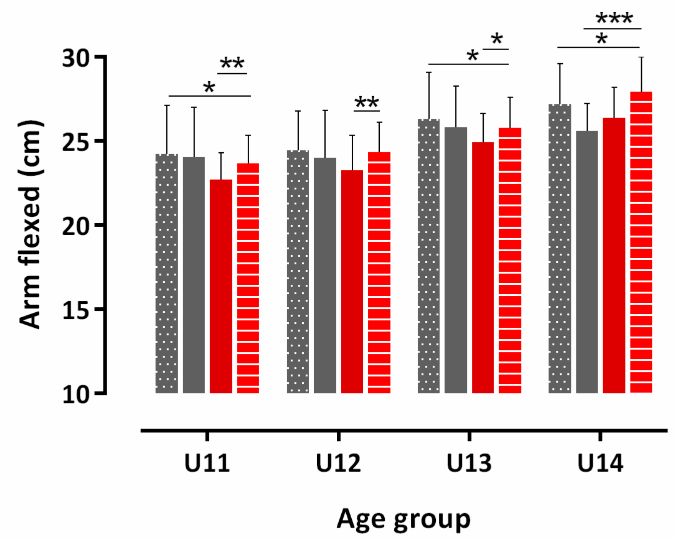


Figure 4.2.4. Differences in arm relaxed circumferences between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size



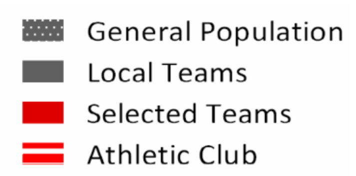


Figure 4.2.5. Differences in arm flexed circumferences between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size

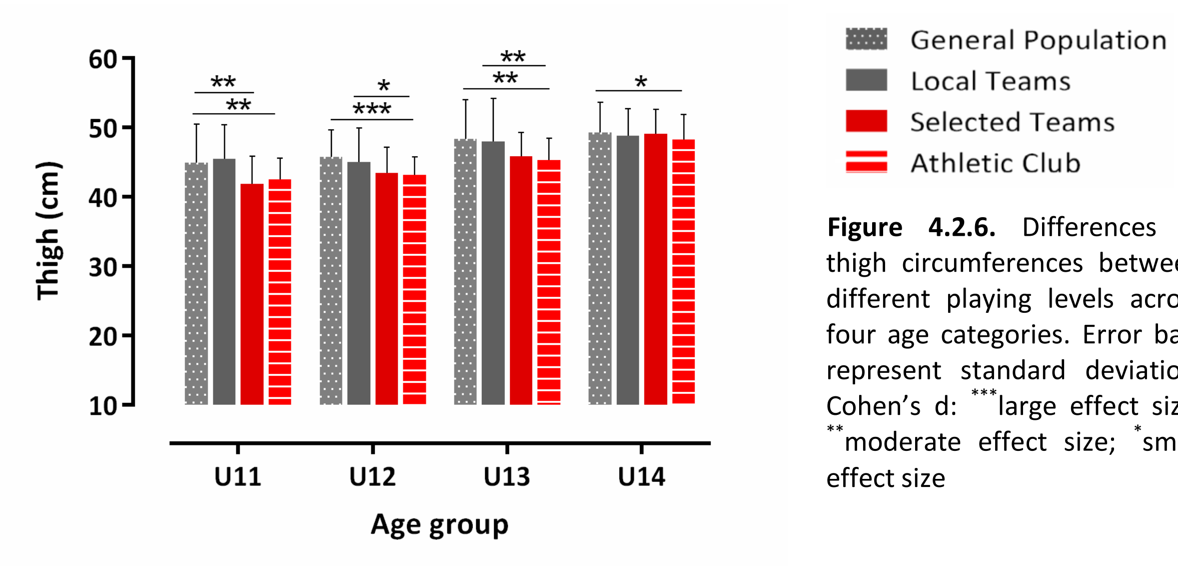


Figure 4.2.6. Differences in thigh circumferences between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size

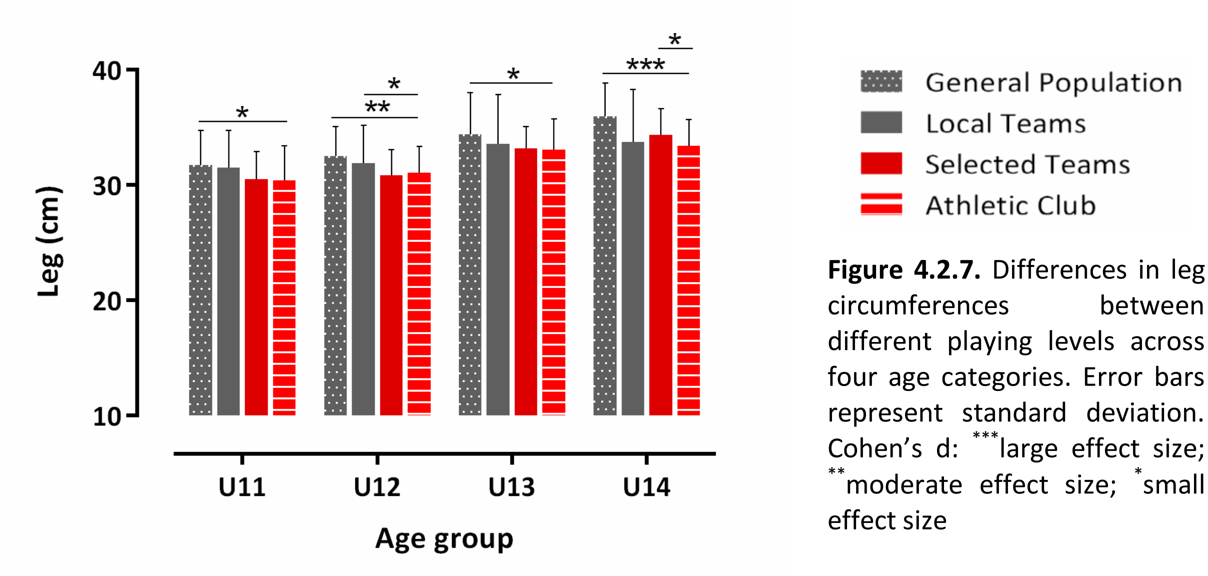


Figure 4.2.7. Differences in leg circumferences between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size

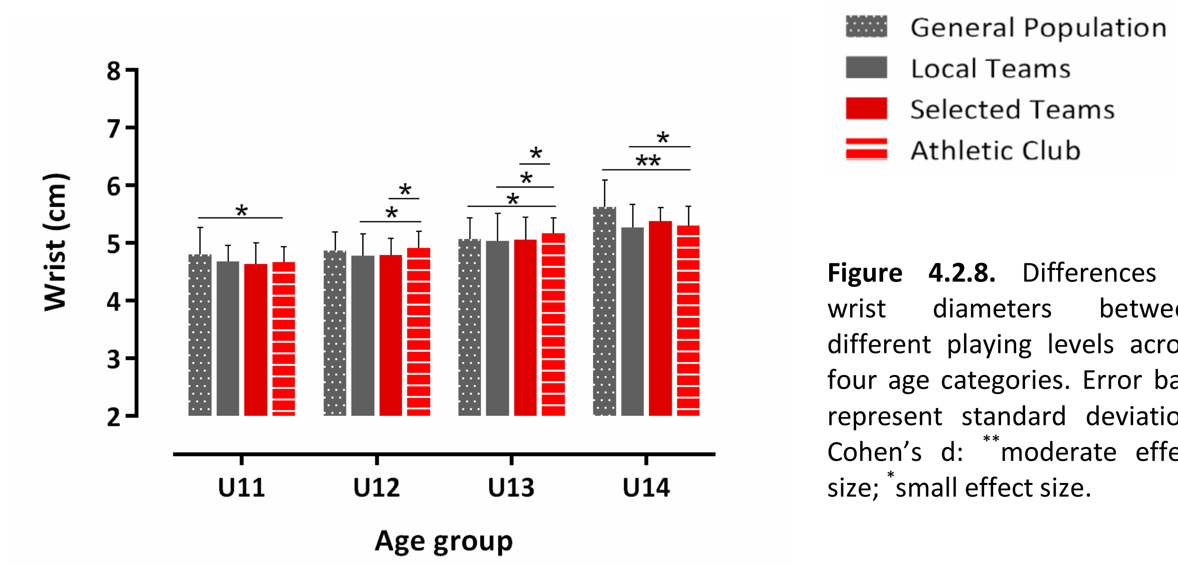


Figure 4.2.8. Differences in wrist diameters between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: **moderate effect size; *small effect size.

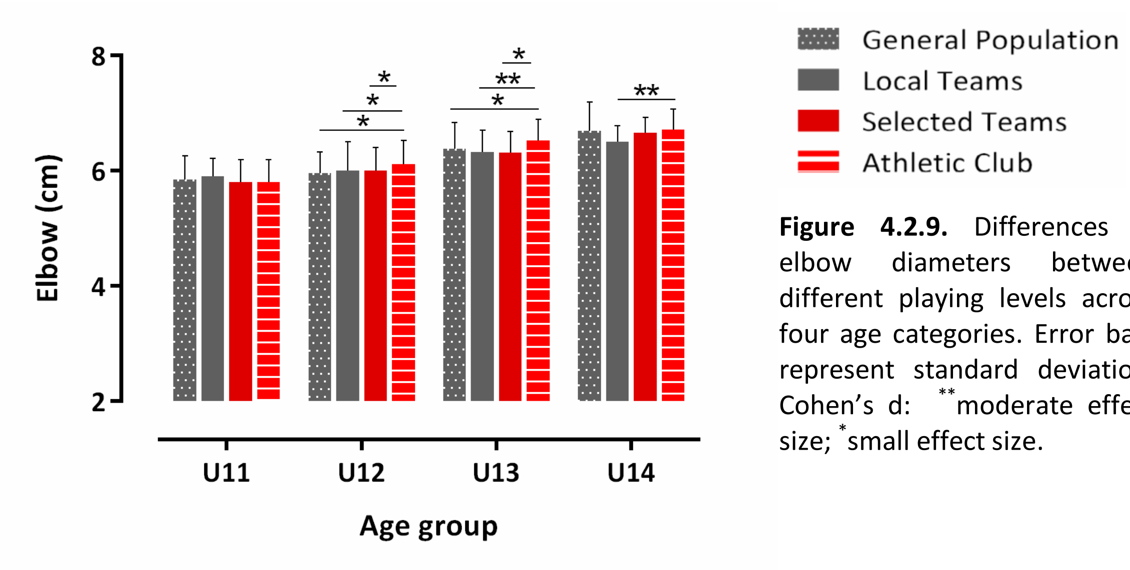


Figure 4.2.9. Differences in elbow diameters between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: **moderate effect size; *small effect size.

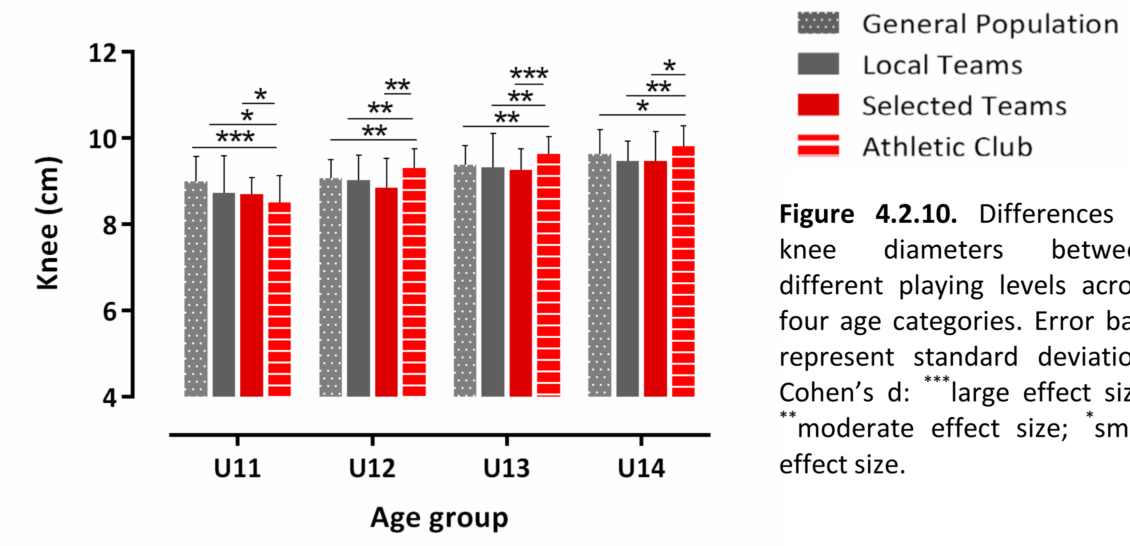


Figure 4.2.10. Differences in knee diameters between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

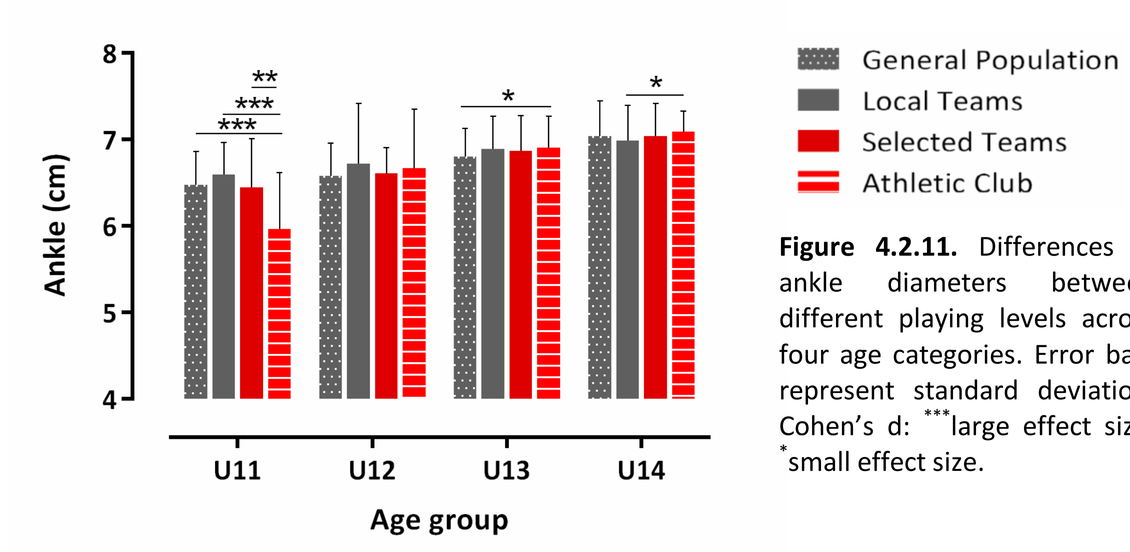


Figure 4.2.11. Differences in ankle diameters between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; *small effect size.

4.2.3.3. Skinfold thickness

Overall, amongst all the age groups Athletic Club´s players and players from *DENA* players had significantly lower values of skinfold thicknesses at the 6 sites (Figures 4.2.12 to 4.2.17) and, consequently, they also had the smallest of ∑ skinfolds, ∑ trunk skinfolds and ∑ extremities skinfolds (Figures 4.2.18 to 4.2.20). Nevertheless, while in the U11 age group the ∑ skinfolds and the ∑ extremities skinfolds were similar in both the Athletic Club and *DENA* players, as age increases, they became significantly different (d= 0.48 - 1.32).

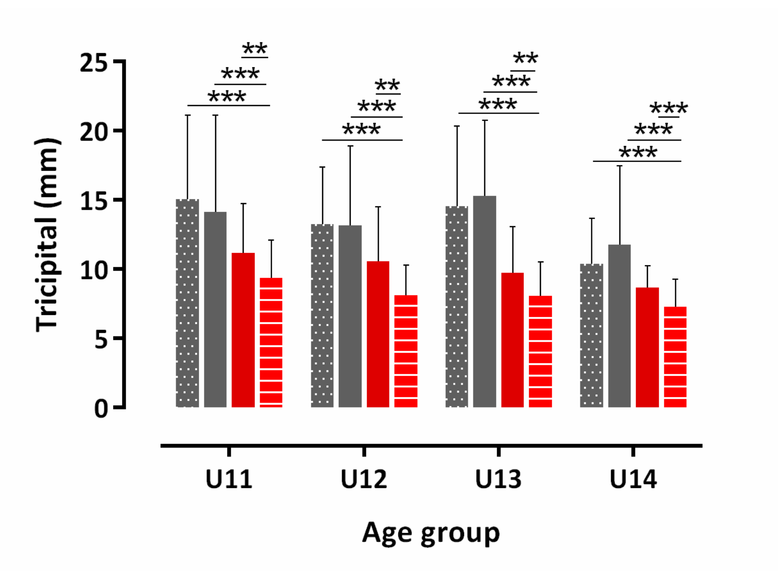


Figure 4.2.12. Differences in tricipital skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen’s d: ***large effect size; **moderate effect size

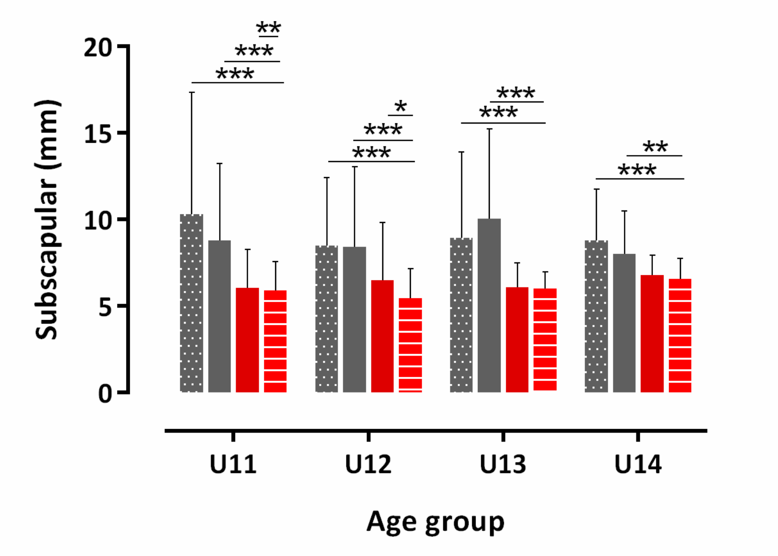


Figure 4.2.13. Differences in subescapular skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen’s d: ***large effect size; **moderate effect size; *small effect size.

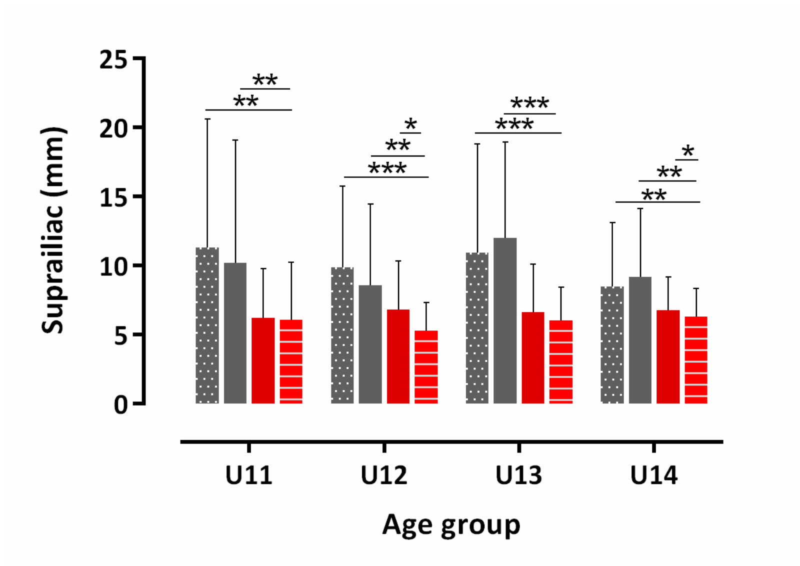


Figure 4.2.14. Differences in suprailiacal skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

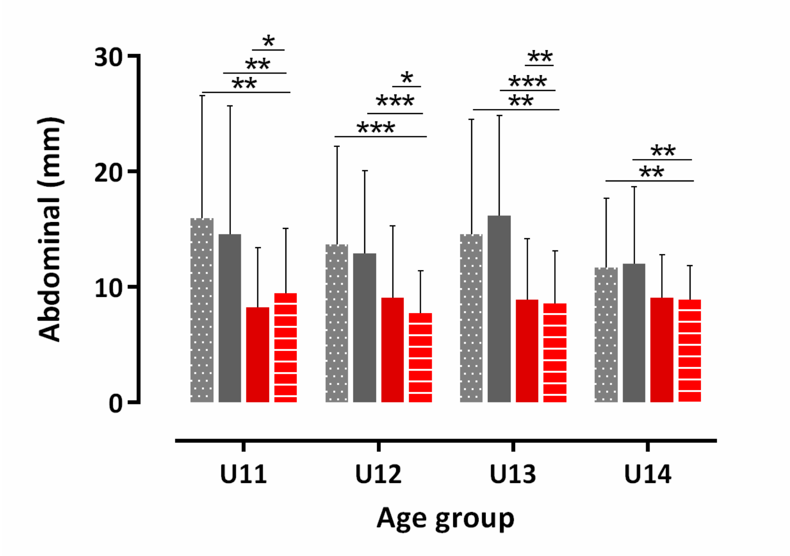


Figure 4.2.15. Differences in abdominal skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

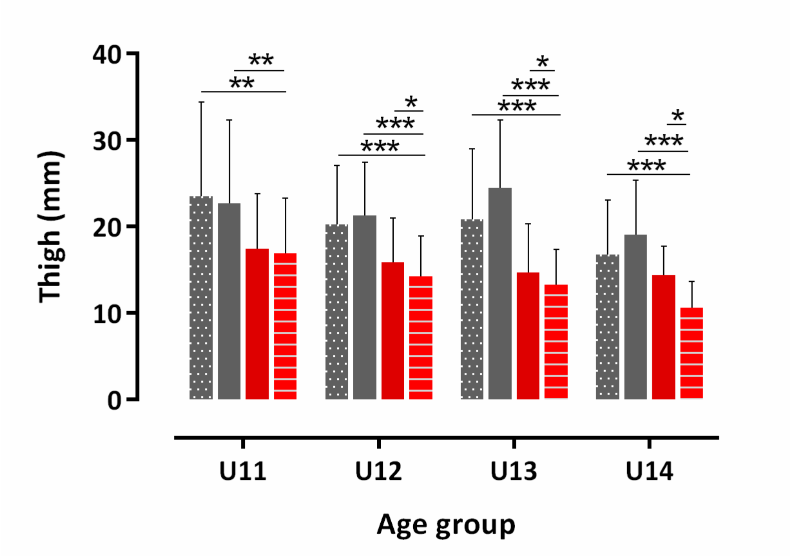


Figure 4.2.16. Differences in thigh skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect siz

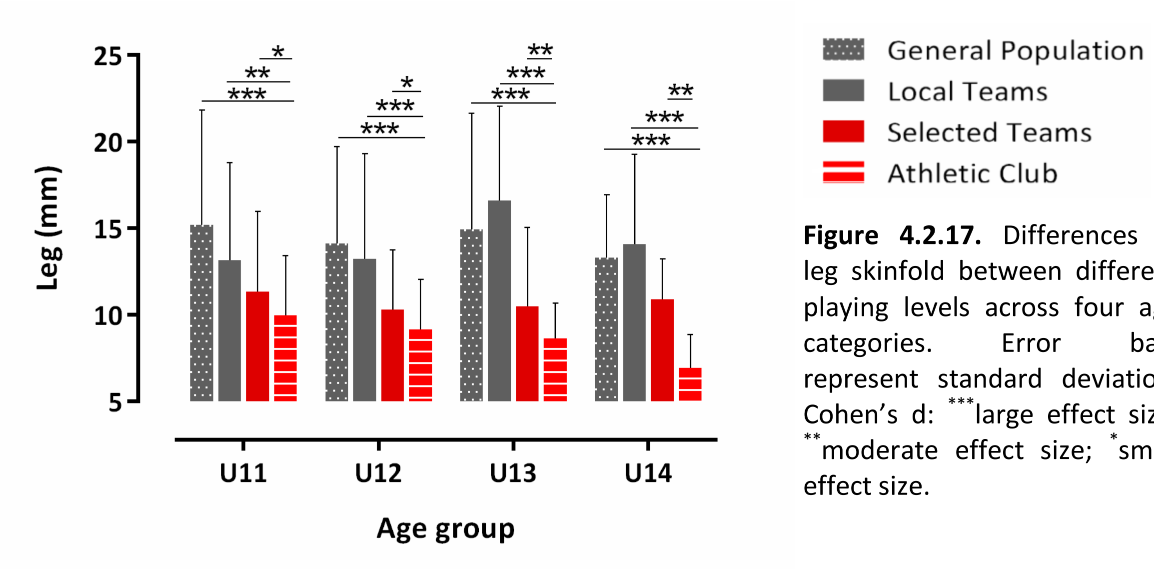


Figure 4.2.17. Differences in leg skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

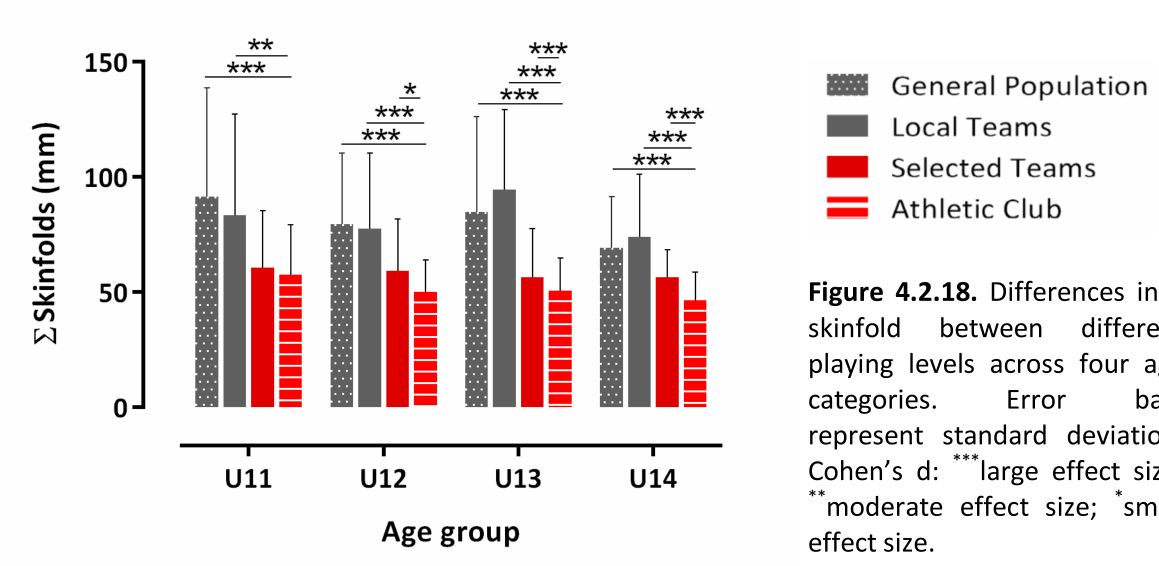


Figure 4.2.18. Differences in ∑ skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

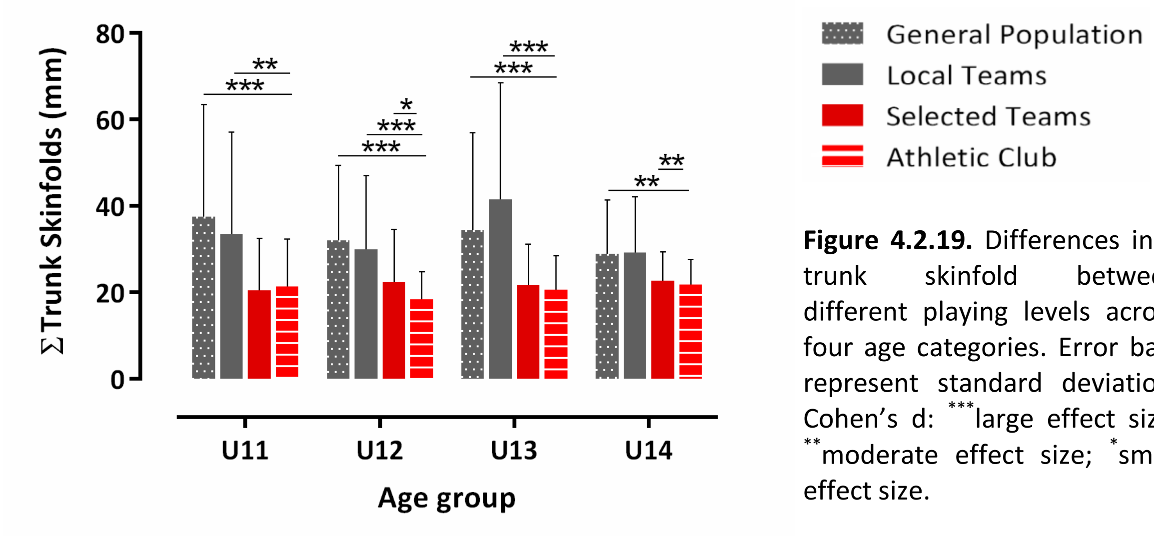


Figure 4.2.19. Differences in ∑ trunk skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

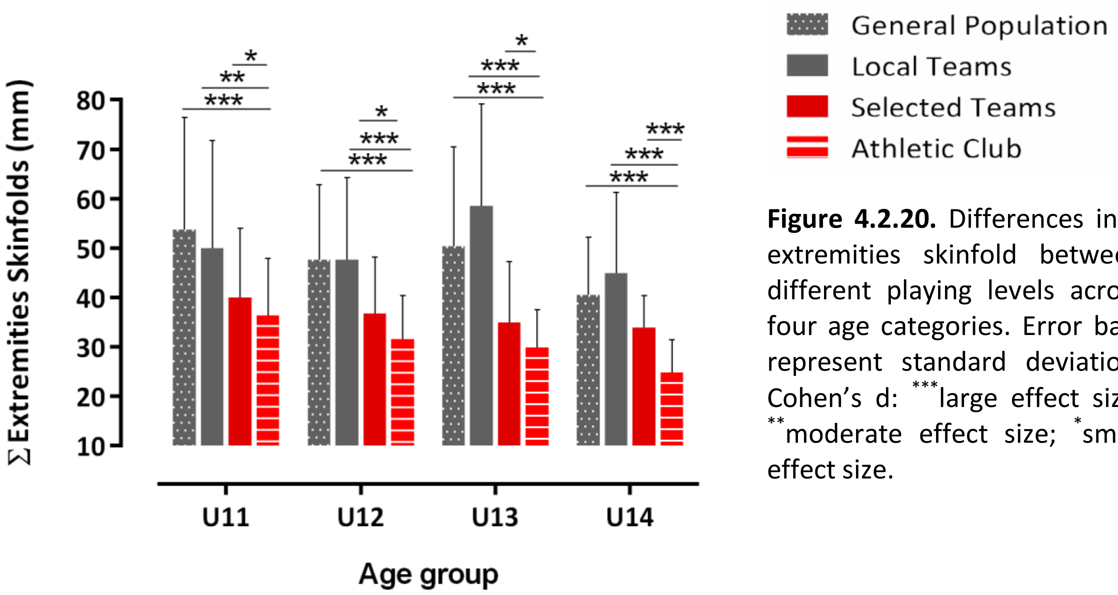


Figure 4.2.20. Differences in ∑ extremities skinfold between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

4.2.3.4. Body composition

Regarding the percentages of the different components of the body, Athletic Club´s players had the lowest fat and the highest muscle percentages (d= 0.24 - 1.35 and d= 0.40 - 1.47, respectively) compared to the rest of the level groups and among all the age groups (Figures 4.2.21 and 4.2.23). In contrast, as it is shown in Figure 4.2.22, the results of the bone percentage fluctuated among the age groups. Thus, in the U11, U12 and U13 groups bone percentage was higher in the Athletic Club´s players when compared to the others. Nevertheless, in the U14 group, Athletic Club´s players had the lowest bone percentage values (d= 0.21 - 0.93).

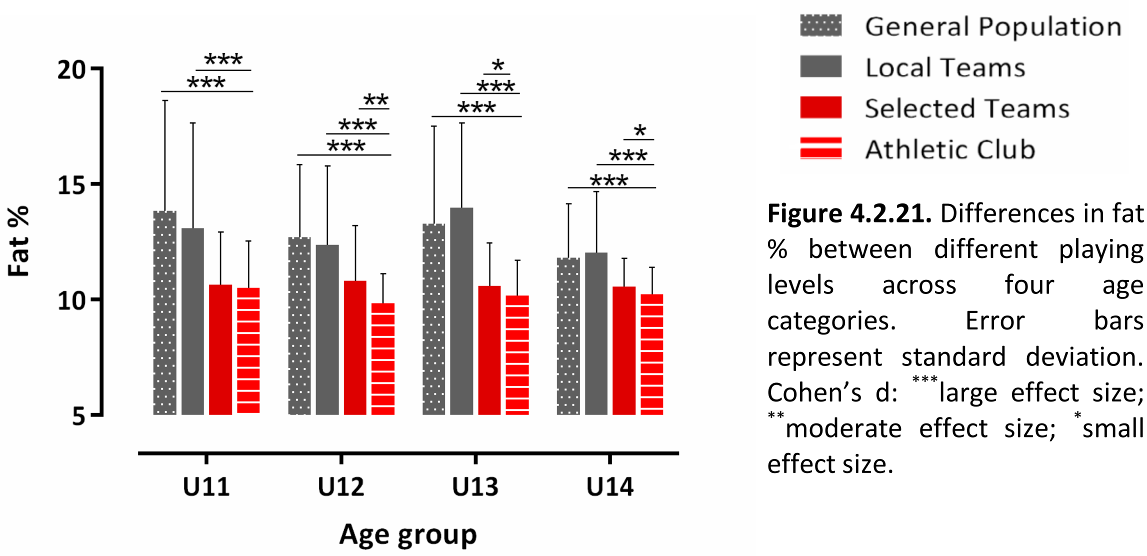


Figure 4.2.21. Differences in fat % between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

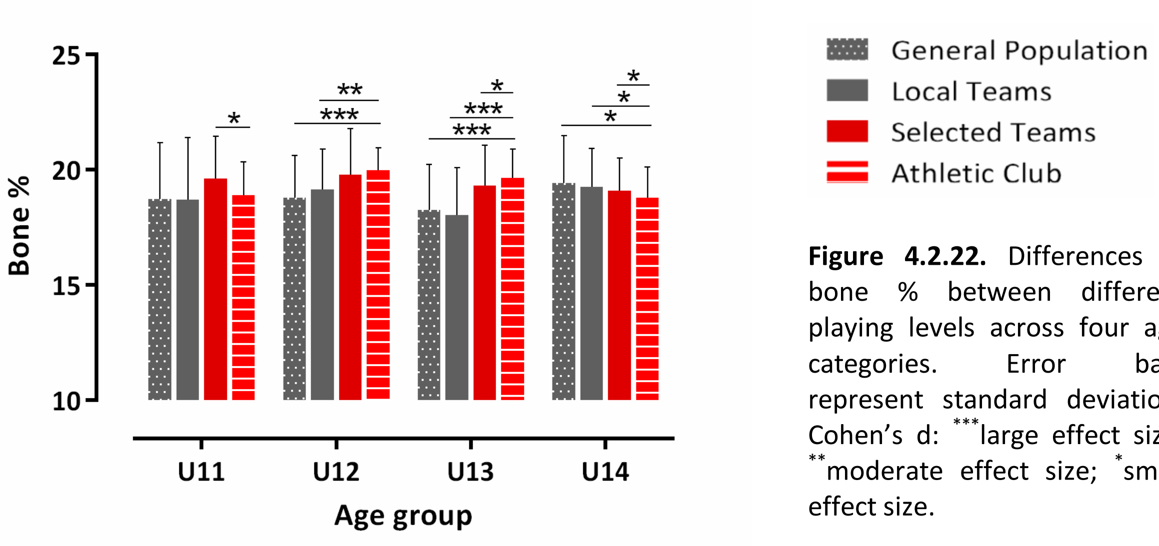


Figure 4.2.22. Differences in bone % between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

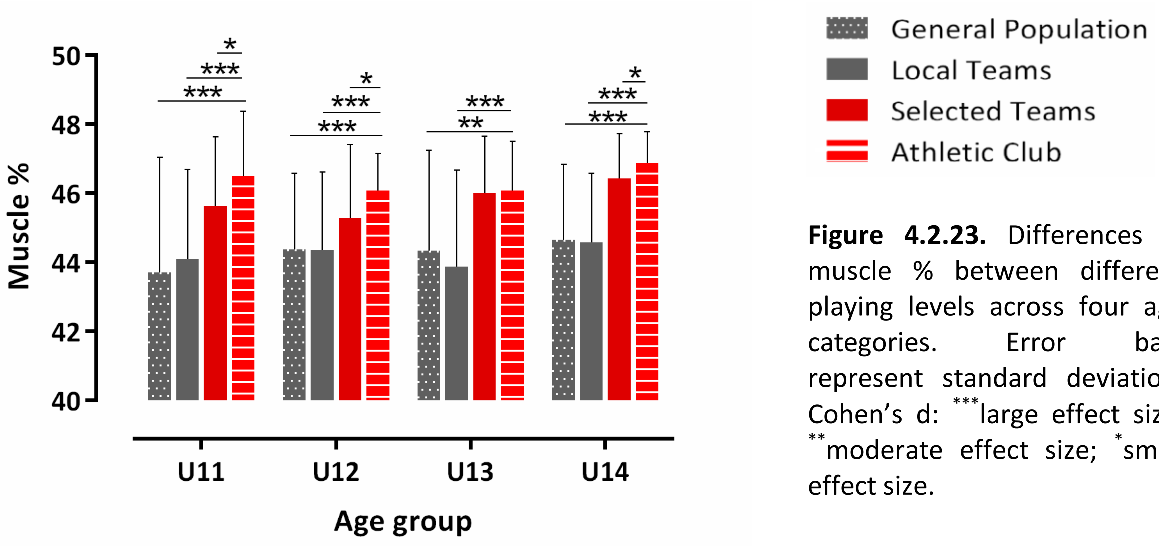


Figure 4.2.23. Differences in muscle % between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

4.2.3.5. Somatotype

The ectomorphy, mesomorphy and endomorphy scores are shown in Figures 4.2.24 to 4.2.28. All the groups revealed predominance for mesomorphy. In fact, as age increased mesomorphy was the main somatotype in all the age groups. However, in comparison with the other groups, Athletic Club´s soccer players were more ectomorphyc. Similarly, *DENA* players presented higher values of ectomorphy than the other groups.

Thereby, Athletic Club players were mainly mesomorph-ectomorph while *DENA* players were ecto-mesomorph. In contrast, higher values of the endomorph component were noticed in soccer players of lower level (Local Team players) and the General Population. In consequence, the principal somatotype of these two groups was endo-mesomorphyc.

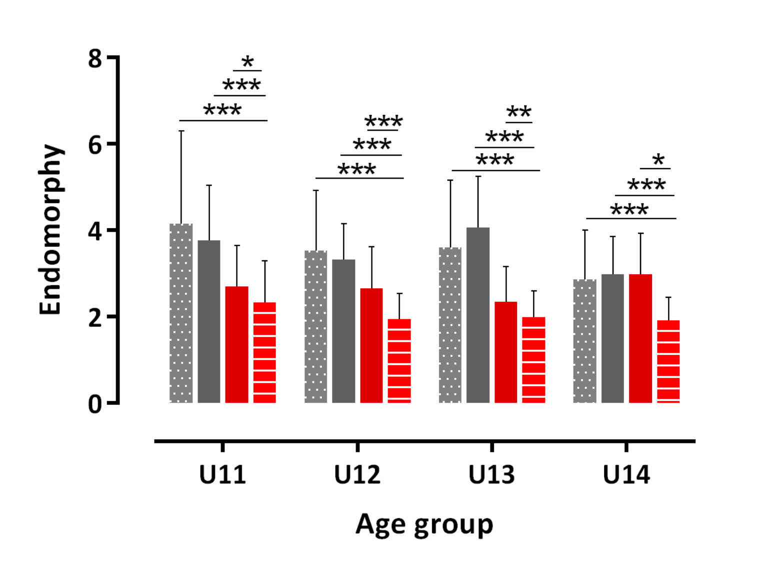


Figure 4.2.24. Differences in endomorphy between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

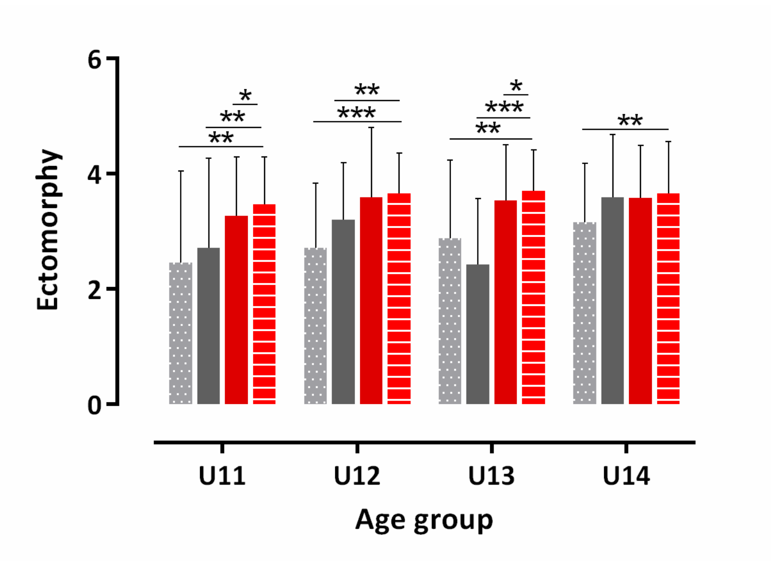


Figure 4.2.25. Differences in ectomorphy between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

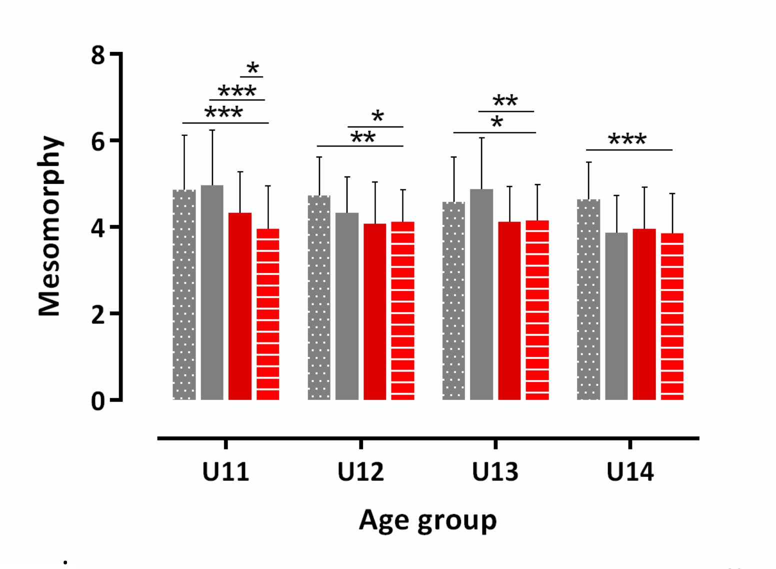


Figure 4.2.26. Differences in mesomorphy between different playing levels across four age categories. Error bars represent standard deviation. Cohen's d: ***large effect size; **moderate effect size; *small effect size.

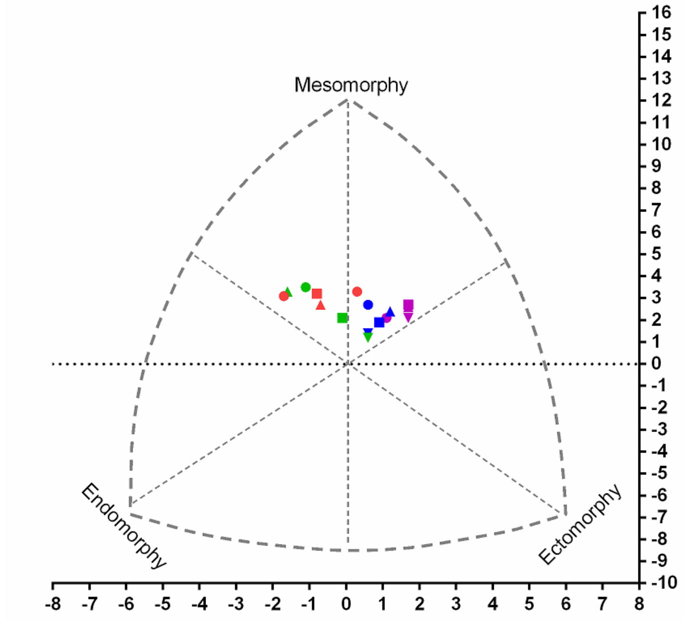


Figure 4.2.27. Somatotype distributions of players by playing level and age group shown on the somatochart.

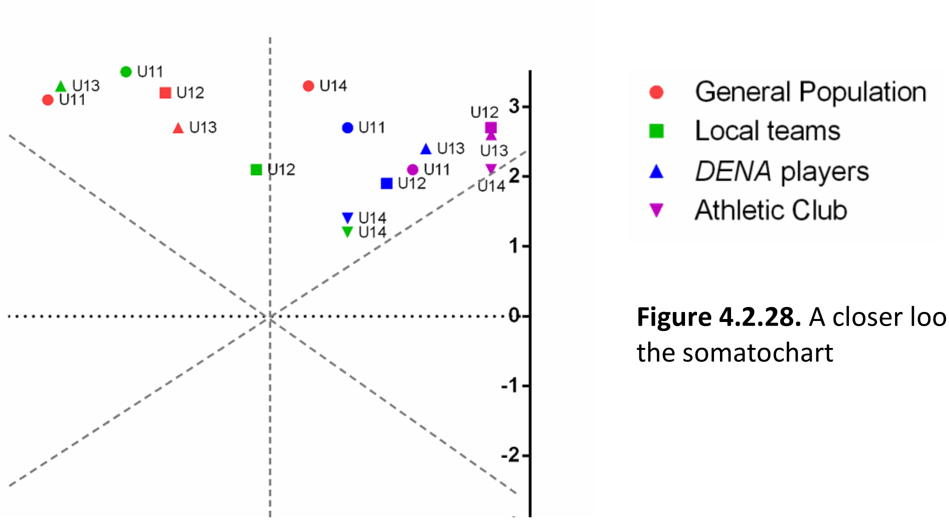


Figure 4.2.28. A closer look of the somatochart

4.2.4. Discussion

In the present study, we identified significant anthropometrical differences between four different sports levels (the General Population, Local Teams players, *DENA* players and Athletic Club players) among four different age groups (U11, U12, U13 and U14).

Larger body size is an important factor associated with progression in a soccer career (Figueiredo et al., 2009; Le Gall et al., 2010). In agreement with this statement, the Athletic Club players in the present study were found to be taller than the rest of the groups among all the ages. However, although in the literature authors have reported that soccer players tend to be heavier than their age matched peers (Gil et al., 2010; Le Gall et al., 2010; Malina et al., 2000), in our study the Athletic Club players tend to be lighter than the rest of the groups in the youngest ages and became significantly heavier as age increased. Nonetheless, BMI results indicate that Athletic Club players had the lowest values among all the ages. Previously, it has been reported that in children and adolescents BMI is probably more of an indicator of heaviness and indirectly of body fat (Malina, Bouchard, & Bar-Or, 2004). Thus, this is consistent with the notion that young male athletes tend to be taller than average and to have body weights that approximate the average (Malina et al., 2011). This suggests that, even if size is important for selection (Malina et al., 2000), having lower values of fat seems to be important, at least at the youngest ages.

Similar to what happened in body size, larger measurements in soccer players compared to the general population have been observed by other authors in circumferences and diameters (Canhadas et al., 2010; Gil et al., 2010). In agreement with this statement, in the present study the Athletic Club players have larger diameters. However, it was surprising to observe that, while in most of the circumferences (arm relaxed, thigh and leg) the General Population and the Local Teams players had the largest values, in the arm flexed circumference Athletic Club players had the largest ones.

The smaller circumferences observed in the Athletic Club players may be partially explained by lower levels of subcutaneous fat whereas the higher values of flexed arm circumferences were possibly caused by muscle hypertrophy as a response to training.

When skinfold thickness were closely analyzed, parameters indicate that both the General Population and the Local Teams players had significantly higher values of fat adiposity than the Athletic Club players in the ∑ extremities skinfold among all the age groups (48.06 ± 5.64 and 49.53 ± 6.87 mm *vs.* 33.51 ± 3.26 mm, respectively). Previously, in a study performed with young soccer players of a non-elite soccer club Gil et al., (2010) reported that young soccer players may suffer a decrement of limb fat, particularly in the lower limbs, which could be due to their training programs and the matches they play. Thus, as mentioned above, presumably the smaller circumferences observed in our study in the *DENA* players and the Athletic Club players may be likely due to the fact that they received a more soccer specific training and, therefore, the fat accumulated in the limbs may be lower than in the General Population and the Local Teams players.

Other authors had already reported the importance of the amount of body fat in the selection of young soccer players (Figueiredo et al., 2011). In the current study, Athletic Club players and the *DENA* players had the smallest ∑ skinfold, ∑ trunk skinfold and ∑ extremities skinfold among all the age groups. However, it is interesting to note that although in the youngest age groups skinfold thickness results were similar in both groups, differences become larger as age increased: Athletic Club players had significantly less amount of fat than the *DENA* players. Thus, it seems that as age increases selection becomes more difficult and, therefore, players with less amount of fat are chosen to play in higher levels. Furthermore, Athletic Club players showed significantly less amount of fat in the ∑ extremities skinfold than the *DENA* players reinforcing the idea that a more specific training may lead to a decrement of limb fat (presumably in the lower limbs).

Another issue that is worth mentioning is the absence of differences between the General Population and the Local Teams players in regard to skinfold thickness. Indeed, the amount of body fat and the body fat distribution appeared to be quite similar in both groups. This information is surprising since the Local Team players played soccer regularly. Nowadays, obesity and its related disorders in puberty and adolescence are an important public health issue and sport has been meant to be a promising setting for obesity prevention (Gil et al., 2010). Nevertheless, taking into account the results of the present study, it seems that regular participation in a sport per se cannot guarantee the loose of fat in children. Indeed, previous research has demonstrated that even in highly trained athletes adiposity affects health and performance (Fedor & Gunstad, 2013). Moreover, in a recent study performed with 83 elite male athletes results indicated that, even in those individuals participating in moderate-to-vigorous physical activity, the risk of having increased adiposity increased simply by more sedentary behaviors (sitting, watching TV, etc.) (Júdice, Silva, Magalhães, Matias, & Sardinha, 2014).

When analyzing body composition, specifically fat percentage, Athletic Club players and *DENA* players appeared to have significantly lower values than the rest of the groups among all the ages. This was to be expected as previous studies have shown that soccer players´ percentage of fat is around 11 %, which is lower than that in the general population (Gil et al., 2010; Vänttinen, Blomqvist, Nyman, & Häkkinen, 2011). Interestingly, whereas in the General Population and in the Local Players as age increased the fat percentage decreased, little changes were observed in the *DENA* players and in the Athletic Club players. This supports previous findings that suggest, firstly, that the lowest percentages of body fat can be detected at the age of 16-17 years in the general population (Malina, Bouchard, & Bar-Or, 2004) and, secondly, that the soccer players´ percentage of body fat was so low at the youngest ages that the normal decrease of body fat related to growth during puberty did not occur (Vänttinen et al., 2011). Athletic Club players have the highest values of bone and muscle percentages among most of the ages.

A study performed with early pubertal boys who played soccer for 3 hours/week over a three year period have already shown that players maintained their fat mass and improved their lean mass whereas their non-active age matched peers increased their body fat percentage and did not change their lean mass (Vicente-Rodriguez et al., 2004). Similar results have been also reported by other authors (Burdukiewicz et al., 2013; Gil et al., 2010). Thus, between groups analysis demonstrated that the Athletic Club players and *DENA* players had less total body fat and greater lean mass than the rest of the groups. Largely, our results agreed with the fact that fat adiposity appears to be an important parameter in the selection of young athletes (Wilmore & Costill, 1999).

Regarding the somatotype, there were not significant differences between the levels among all the age groups. In agreement with what has been reported in the literature, all the groups revealed predominance for mesomorphy (Mirkov et al. 2010; Rienzi et al., 2000). Nevertheless, while a trend for ectomorphy was found in the *DENA* players and the Athletic Club players, Local players and the General Population presented higher levels of endomorphy. On the one hand, these results confirm that high-level soccer players had lower endomorphy scores than the general population (Gil et al., 2010). On the other hand, as endomorphy is a correlate of fat, results are consistent with idea that lower fat percentages associates with better physical performance and, therefore, the young players selected tend to be leaner (Nikolaidis & Vassilios Karydis, 2011).

4.2.5. Conclusion

Overall, the trend observed is consistent with results obtained in other studies were body size appeared to be important for soccer selection and support the idea that young soccer players are bigger and leaner than their age counterparts who never engaged in regular sporting activity. Also, coaches should bear in mind that an excessive amount of fat is one of the most important negative factors related to selection presumably due to the negative influence of fat adiposity in performance. Finally, taking into account the results about fat adiposity indicators, it seems that regular participation in a sport per se cannot guarantee the loose of fat. Therefore, future research using longitudinal studies are needed to provide more information about adequate quantity and quality of physical activity as well as a further insight about sedentary behaviors in order to avoid obesity and overweight in children and adolescents.

CHAPTER 3

SEASONAL MONITORING OF GROWTH AND PERFORMANCE DEVELOMENT OF YOUNG SOCCER PLAYERS OF THE ATHLETIC CLUB

4.3. CHAPTER 3

4.3.1. Introduction

Lately, professional soccer clubs have invested in structured talent identification and talent development programs in search for future professional soccer players. The huge economical and human resource investment for these programs requires objective methods for talent selection and development (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Previously it has been observed that success in soccer appears to be dependent on a variety of factors such as body size and composition, physical fitness (aerobic and anaerobic fitness among others) and skill, behavioral dimensions, and a sense of the game, labeled 'game intelligence' (Reilly, Williams, et al., 2000; Hansen & Klausen, 2004). Importantly, the capacity of soccer players to maintain a good level of physiological fitness throughout the season is vital. Thus, the assessment of physical fitness changes at various moments during the competitive season is of relevance for researchers and coaches to measure the effectiveness of training (Caldwell & Peters, 2009). However, when working with youth soccer players, such changes in performance can be significantly affected by changes in performance affected by growth and maturation (Lloyd et al., 2014).

Maturation has been identified as a significant contributor to aerobic fitness (Carvalho et al., 2011), anaerobic power (Carvalho et al., 2013), explosive power, sprinting (Malina, Eisennman, et al., 2004) and change of direction (Vaeyens et al., 2006). Moreover, in the selection processes the role of physical growth and maturation in soccer appear to be important, as it systematically excludes late maturing boys and favors average and early maturing boys as chronological age and sport specialization increase (Malina et al., 2000). Thus, given the increasing number of pre-adolescent youth who specialize early in soccer, the patterns of physical growth and maturation of young soccer players engaged in organized training programs merit more detailed consideration (Carvalho et al., 2013). Nevertheless, little information is currently available on the effect of growth and maturation on the anthropometrical and physical performance of young elite soccer players of a youth academy during a competitive season.

In the context of youth soccer, research is generally cross- sectional and there is a need for longitudinal approaches as they may provide more information about the development of anthropometrical and physical performance parameters. Despite the amount of information available in young soccer players, little information is currently available on longitudinal data of young elite soccer players in a youth academy (Le Gall et al., 2010). Therefore, the purpose of the present study was to use a mixed cross-sectional and longitudinal approach to observe the changes in anthropometry, physical fitness and maturation in elite young soccer players during a period of 4 competitive seasons and the changes occurred during the period between seasons.

4.3.2. Methodology

Study Design

The present study involves a mixed cross-sectional and longitudinal analysis of the development of players attending to the Athletic Club during 4 years, exactly during the 2009-2010 to 2012-2013 competitive seasons. Thus, the players start being part of the Under-11 (U11) category and, subsequently, they passed through the Under-12 (U12), Under-13 (U13) and Under-14 (U14) categories.

The soccer players were evaluated annually on two occasions: first, at the start of the season (end of September - beginning of October); second, at the end period of the training-season (end of May - beginning of June). The following variables were measured: anthropometry (height, sitting height, body mass, 6 skinfolds, circumferences and diameters; body composition and somatotype were calculated), physical performance tests velocity 15-m (velocity), barrow agility test (agility), Yo-Yo intermittent recovery tests (Level 1) (Yo-Yo IR1), counter-movement jump (CMJ) and hand dynamometry (dynamometry) and salivary hormones concentration (testosterone and dehidroepiandrosterone (DHEA)). Chronological age (CA) and age at peak height velocity (APHV) were calculated.

It is important to highlight that even if all the measurement were carried out twice annually, during the first season (2009-2010) the collection of salivary samples was only carried once: at the beginning of the season. Anyway, all measurements were recorded within a 2-week period and were always taken under the same external conditions.

Sample

The players at the start of the study were part of U11 teams from the professional Basque club Athletic Club of Bilbao. One of the limitations of the present study was the missing values. Firstly, this is occurs due to the fact that in professional clubs youth development programs the selection process excludes players each season and recruits new players over the course of the program. Secondly, some players were injured or drop-out the club during the follow-up. Thereby, only players with results for consecutive test sessions in each season were included in the study. Number of players, CA and corresponding age category in each measurement moment are shown in Table 4.3.1.

Table 4.3.1. Category, number of players and mean age of the players in each season (± SD).

Season	Season 1		Season 2		Season 3		Season 4	
Number of players	27		55		39		27	
Measurement moment	T1	T2	T3	T4	T5	T6	T7	T8
CA (years)	10.41 (0.28)	11.03 (0.28)	11.45 (0.18)	12.03 (0.18)	12.32 (0.34)	13.13 (0.34)	13.53 (0.31)	14.18 (0.31)

CA: Chronological age.

Statistical Analysis

Descriptive statistics for all measurement moments are presented as mean ± standard deviation. A pairwise analysis was employed to establish the percentage change in the variables scores between consecutive sessions. The percentage change was calculated as the mean change across all individuals. Only players with results for consecutive test sessions were included in each pairwise analysis.

This approach provided results showing the percentage change during the season (9 months) and off-seasons (4 months). A one way ANOVA was used to determine if there were any significant differences in the magnitude of the change across different ages. Significance for all the statistical tests was set at $p < 0.05$.

4.3.3. Results

4.3.3.1. Anthropometry, body composition and somatotype

Height, body mass and BMI

Mean measures of height, body mass, sitting height, leg length and BMI are shown by measurement moment for all players in Table 4.3.2 and Figures 4.3.1 and 5.3.2. All measures of body size showed significant differences across ages, indicating a trend for all variables to increase with age.

Pairwise analysis of the mean percentage change in both height and body mass between consecutive measurement moments (season and off-season) are shown in Figures 4.3.3 and 4.3.4. Regarding height, players grew significantly more ($p < 0.001$) during the U13 and the U14 seasons. In regard to percentage changes in body mass, they were considerably higher than those in height, increasing at least 4.61 % during each measurement interval. In addition, percentage changes in body mass were significantly higher in the 13 and 14 seasons when compared to the rest of the measurement moments ($p < 0.001$).

The results for the rate of development in sitting height and leg length are presented in Figures 4.3.5 and 4.3.6. A significant main effect of age was found in both variables ($p < 0.001$ and $p < 0.05$, respectively). In relation to sitting height, although the rate of the changes decrease in the U12 season, in the U14 season the mean change was significantly greater than the rest (4.54 ± 3.01 %).

Conversely, in leg length, players had higher values in the youngest ages (U11 season, U11 and U12 off-seasons and U12 season) when compared with the changes in leg length that occurred in the U14 season. The mean changes were 2.51 ± 3.90 %, 3.83 ± 1.61 %, 2.45 ± 2.37 % and1.64 ± 0.63 % for the U11, U12, U13 and U14 seasons, respectively.

Non-significant differences between the rates of development in BMI were observed (Figure 4.3.7). Nevertheless, there was an overall trend for BMI values to rise with increasing age: from 0.67 ± 3.82 % in the youngest players to 2.35 ± 3.30 % in the eldest ones.

Table 4.3.2. Mean body mass, height, sitting height, leg length and BMI classified according to the measurement moment (± SD).

	U11				U12				U13				U14			
	T1		T2		T3		T4		T5		T6		T7		T8	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Body mass (kg)	26	35.14 (5.17)	26	37.06 (5.52)	53	39.29 (4.90)	53	41.03 (5.08)	39	43.31 (6.40)	39	46.10 (7.17)	27	50.92 (7.95)	27	55.63 (7.82)
Height (cm)	26	141.85 (5.69)	26	144.31 (5.85)	53	148.51 (5.40)	53	151.38 (5.75)	39	154.31 (6.91)	39	157.79 (6.84)	27	163.04 (7.70)	27	168.01 (6.92)
Sitting height (cm)	26	70.00 (3.16)	26	71.85 (3.60)	53	72.90 (2.98)	53	73.32 (3.20)	39	75.31 (3.76)	39	76.97 (4.11)	27	78.51 (4.79)	27	82.62 (4.35)
Leg lenght (cm)	26	71.85 (3.60)	26	73.47 (3.32)	53	76.42 (3.66)	53	78.06 (3.67)	39	79.79 (3.93)	39	80.82 (3.68)	27	84.53 (4.41)	27	85.39 (3.76)
BMI (kg/cm^2)	26	17.38 (1.47)	26	17.71 (1.57)	53	17.76 (1.44)	53	17.85 (1.39)	39	18.09 (1.35)	39	18.41 (1.48)	27	19.04 (1.52)	27	19.62 (1.64)

BMI: body mass index.

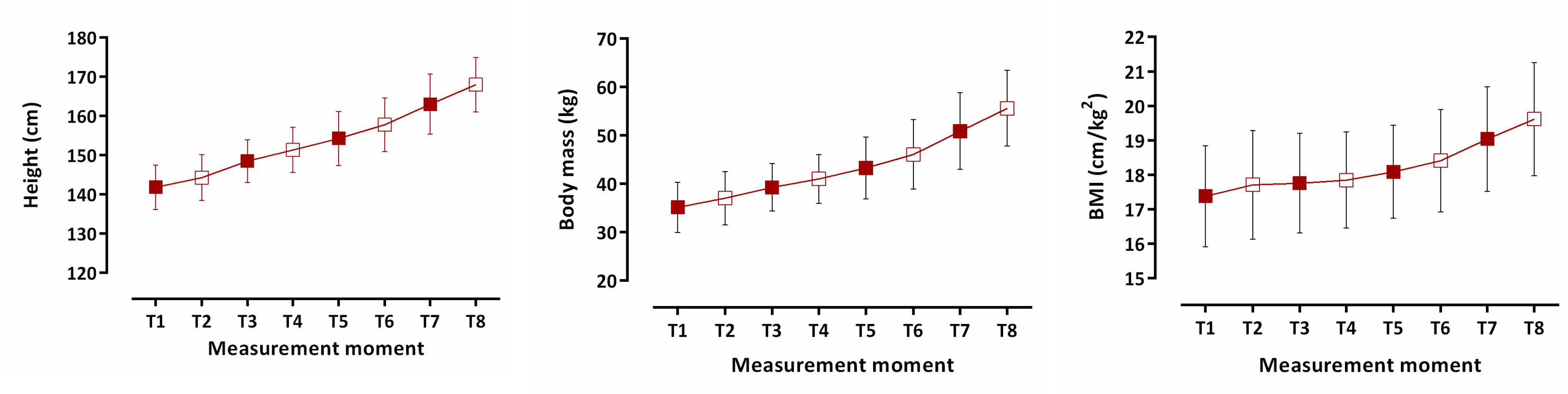


Figure 4.3.1. Mean values in height, body mass and BMI (body mass index) at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation.

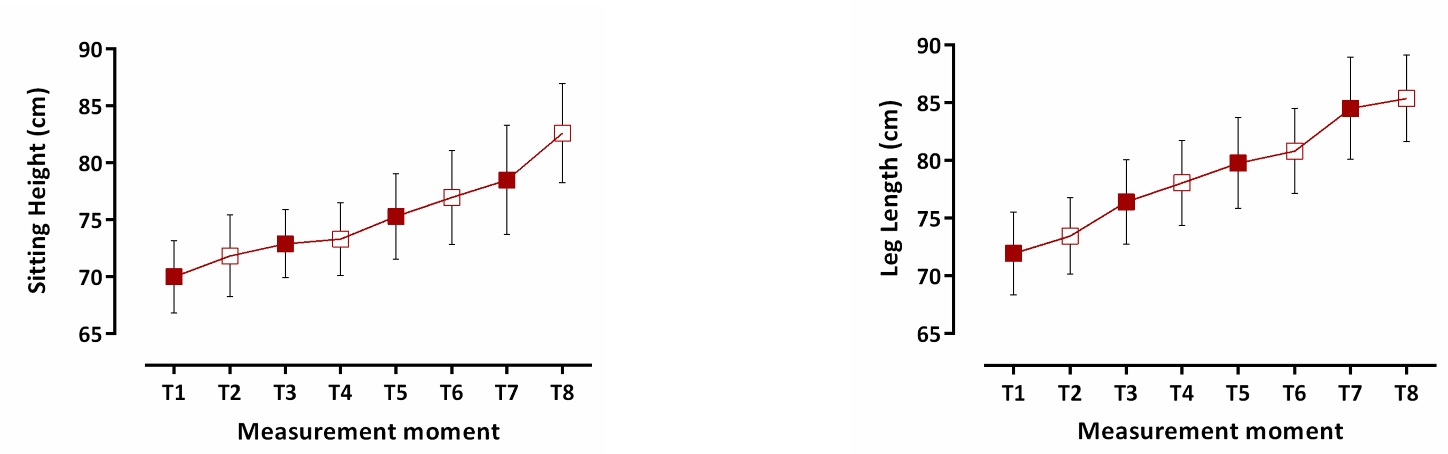


Figure 4.3.2. Mean values in sitting height and leg length at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation.

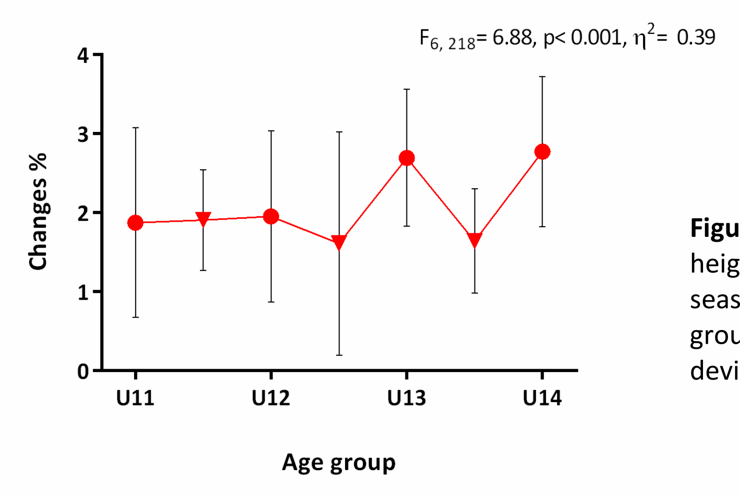


Figure 4.3.3. Percentage changes in height during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

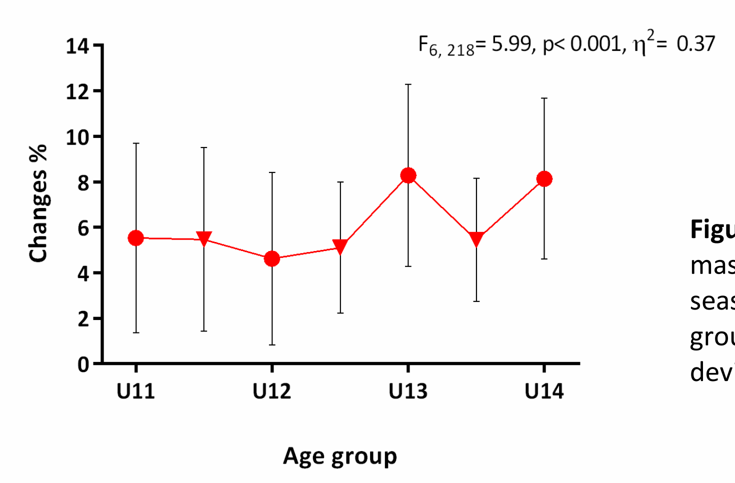


Figure 4.3.4. Percentage changes in body mass during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

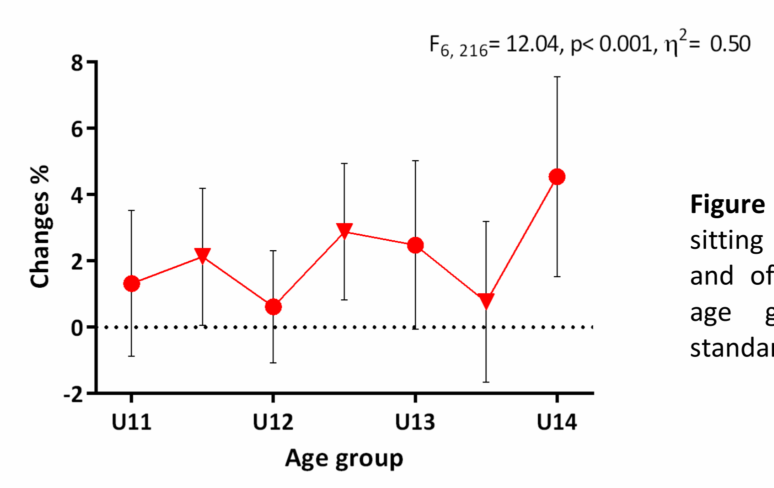


Figure 4.3.5. Percentage changes in sitting height during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

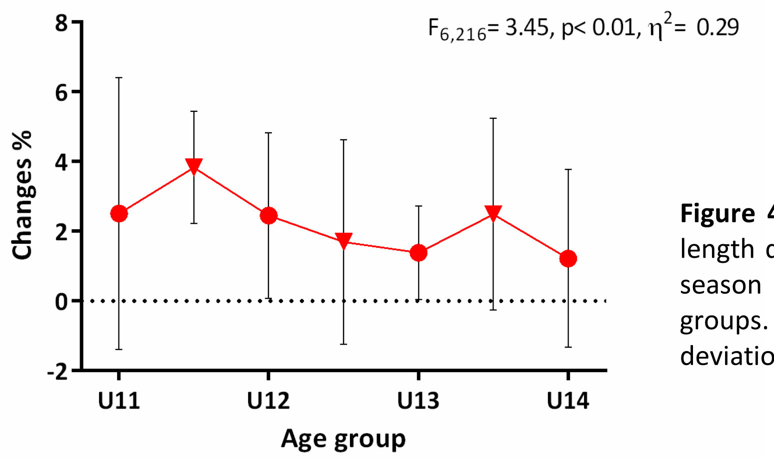


Figure 4.3.6. Percentage changes in leg length during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

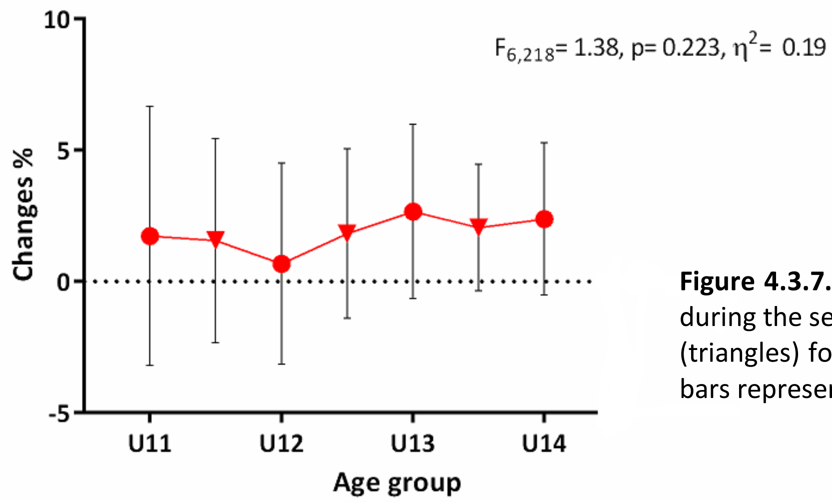


Figure 4.3.7. Percentage changes in BMI during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

Skinfold thickness

Mean measures of ∑ skinfolds, ∑ trunk skinfolds and ∑ extremities skinfolds are shown by measurement moment for all players in Table 4.3.3 and Figure 4.3.11. In addition, significant differences between the rates of change were observed in ∑ skinfolds, ∑ extremities skinfolds ($p < 0.001$) and ∑ trunk skinfolds ($p < 0.01$) (Figures 4.3.8 to 4.3.10). Players had significantly higher mean percentage change values in the U13 season in ∑ Skinfolds and ∑ trunk skinfolds, 6.76 ± 13.28 % and 11.39 ± 14.46 %, respectively.

Table 4.3.3. Mean skinfold thickness classified according to the measurement moment (± SD).

	U11				U12				U13				U14			
	T1		T2		T3		T4		T5		T6		T7		T8	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
∑ skinfolds (mm)	26	54.91 (24.42)	26	60.04 (21.66)	53	57.74 (21.49)	53	55.38 (20.08)	39	49.18 (13.05)	39	50.91 (12.23)	27	50.60 (14.28)	27	48.96 (13.78)
∑ trunk Skinfolds (mm)	26	18.64 (8.02)	26	19.95 (8.05)	53	21.42 (10.94)	53	20.11 (9.11)	39	17.85 (5.08)	39	19.08 (5.42)	27	20.67 (7.86)	27	21.17 (6.79)
∑ extremities Skinfolds (mm)	26	36.27 (16.92)	26	40.09 (14.52)	53	36.32 (11.66)	53	35.26 (12.02)	39	31.33 (8.80)	39	31.82 (7.98)	27	29.93 (7.68)	27	27.79 (8.01)

∑ skinfolds: Total sum of skinfold thickness; ∑ trunk skinfolds: sum of trunk skinfold thickness; ∑ extremities skinfolds: sum of extremities skinfold thickness.

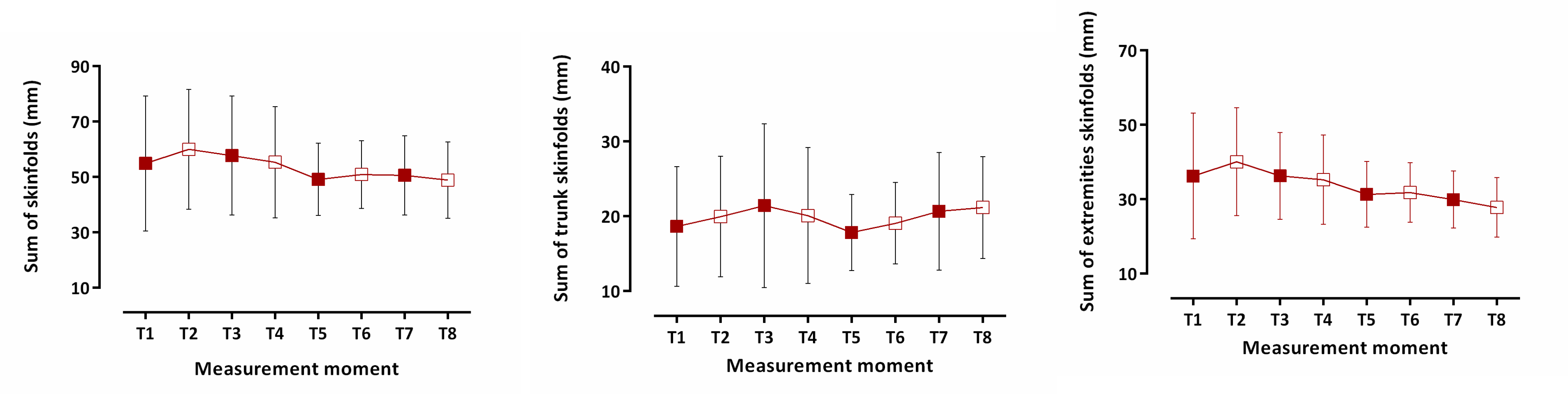


Figure 4.3.11. Mean values in ∑ skinfolds, ∑ trunk skinfolds and ∑ extremities skinfolds at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation

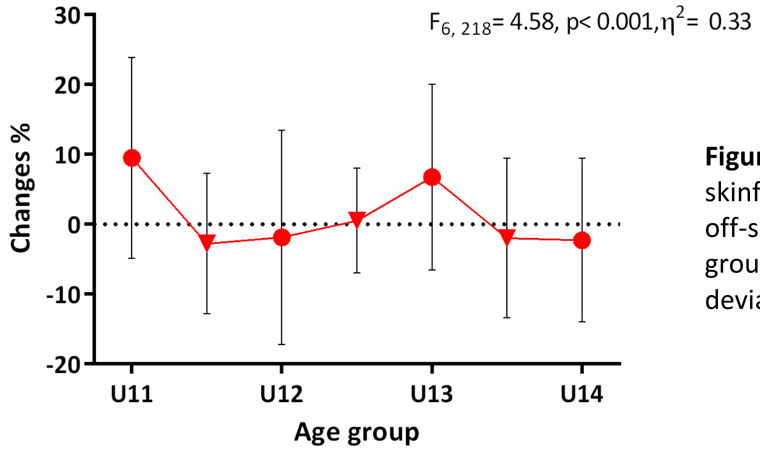


Figure 4.3.8. Percentage changes in ∑ skinfolds during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

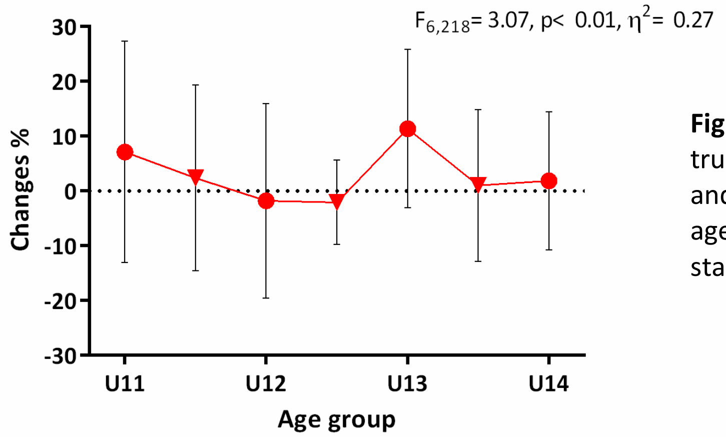


Figure 4.3.9. Percentage changes in ∑ trunk skinfolds during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

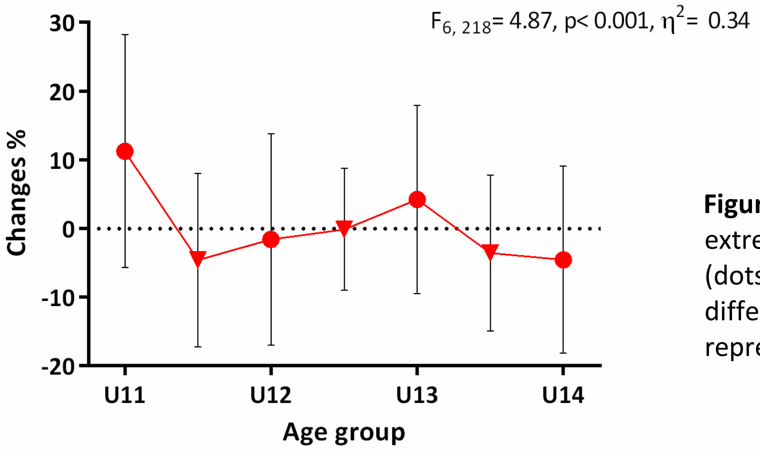


Figure 4.3.10. Percentage changes in ∑ extremities skinfolds during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

Mean measures of fat %, bone % and muscle % are shown by measurement moment for all players in Table 4.3.4 and Figure 4.3.12. In regard to percentage changes in fat % (Figure 4.3.13), significant differences were observed between moments ($p< 0.05$). Results were similar to those observed in the skinfold thickness indicators: the U13 season had significantly higher values of mean percentage changes (3.36 ± 5.13 %) when compared with the rest of the seasons.

The rate of change in bone % is shown in Figure 4.3.14. Significant differences were detected between seasons. Precisely, percentage changes in the U11 and the U12 seasons were significantly higher than in the rest of the seasons (12.21 ± 7.22 % and 5.94 ± 7.81 %, respectively).

As it can be observed in Figure 4.3.15, there were significant differences between the rates of development in muscle % ($p< 0.001$). Thereby, there was a significant tendency for greater improvement at the end of the U11 season (6.86 ± 5.54 %). Subsequently, in the U12 season, a decrease in the mean changes was observed (2.81 ± 4.27 %). Nevertheless, values started increase at the end of the aforementioned season with the tendency to rise as age increased (2.81 ± 4.27 % to 8.84 ± 4.99 %).

Somatotype

Mean measures of endomorphy, mesomorphy and ectomorphy are shown by measurement moment for all players in Table 4.3.5 and Figure 4.3.16. Non-significant differences were observed among seasons. However, players become less endomorph and more mesomorph as age increased. Moreover, a predominance of mesomorphy was observed in all the age groups.

Table 4.3.4. Mean body composites classified according to the measurement moment (± SD).

	U11				U12				U13				U14			
	T1		T2		T3		T4		T5		T6		T7		T8	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Fat %	26	10.11 (2.13)	26	10.28 (1.75)	53	10.49 (2.03)	53	10.21 (1.80)	39	9.73 (1.03)	39	9.94 (1.06)	27	10.17 (1.54)	27	10.21 (1.37)
Bone %	26	17.98 (1.13)	26	20.06 (1.35)	53	18.89 (1.45)	53	19.92 (1.38)	39	20.05 (0.89)	39	20.04 (1.19)	27	19.64 (1.27)	27	18.88 (2.36)
Muscle %	26	47.80 (1.53)	26	45.56 (1.21)	53	46.50 (1.88)	53	45.77 (1.46)	39	46.15 (1.02)	39	45.68 (1.41)	27	46.09 (1.42)	27	46.82 (2.07)

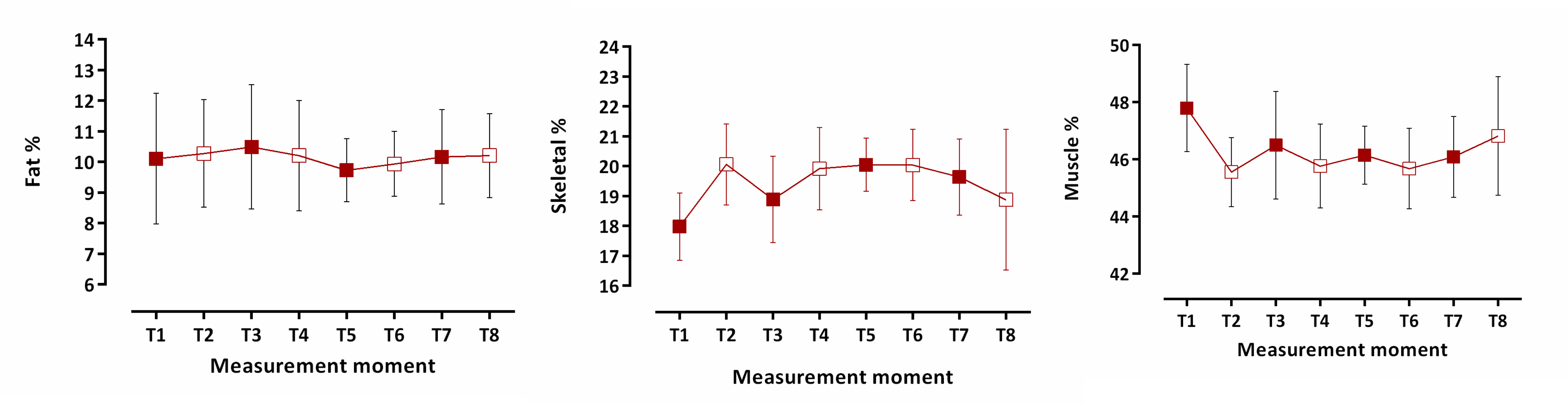


Figure 4.3.12. Mean values in body composites at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation.

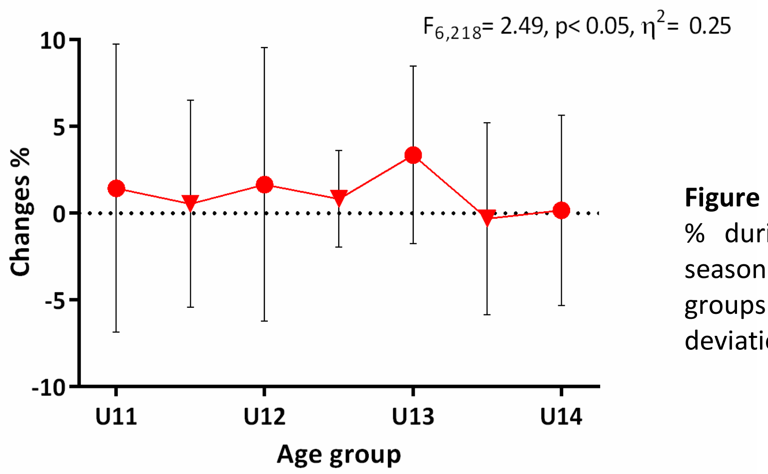


Figure 4.3.13. Percentage changes in fat % during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

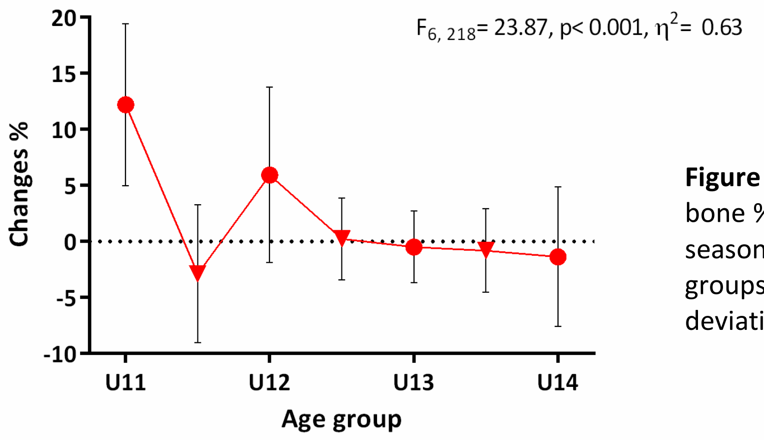


Figure 4.3.14. Percentage changes in bone % during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

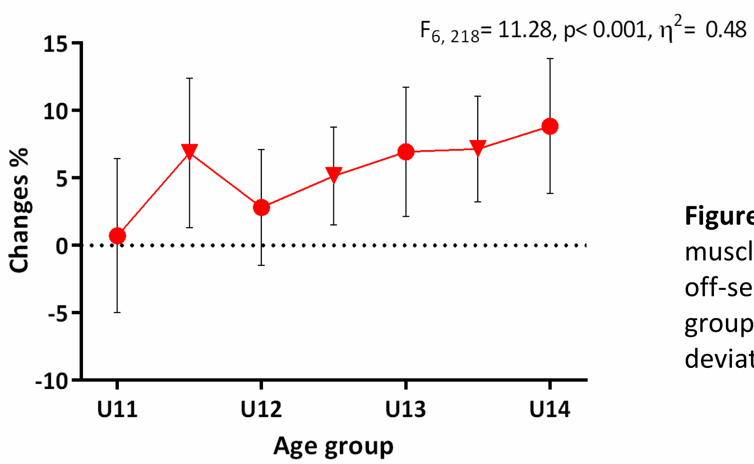


Figure 4.3.15. Percentage changes in muscle % during the season (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation

Table 4.3.5. Mean somatotype classified according to the measurement moment (± SD).

	U11				U12				U13				U14			
	T1		T2		T3		T4		T5		T6		T7		T8	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Endomorphy	26	2.29 (1.15)	26	2.37 (0.92)	53	2.34 (0.95)	53	2.18 (0.84)	39	1.90 (0.51)	39	1.98 (0.51)	27	1.99 (0.62)	27	1.97 (0.68)
Mesomorphy	26	3.73 (0.52)	26	4.45 (0.64)	53	3.90 (1.01)	53	4.17 (0.74)	39	4.13 (0.74)	39	4.18 (0.65)	27	4.15 (0.84)	27	3.78 (0.83)
Ectomorphy	26	3.21 (0.75)	26	3.20 (0.83)	53	3.46 (0.82)	53	3.61 (0.85)	39	3.67 (0.71)	39	3.72 (0.69)	27	3.71 (0.71)	27	3.72 (0.81)

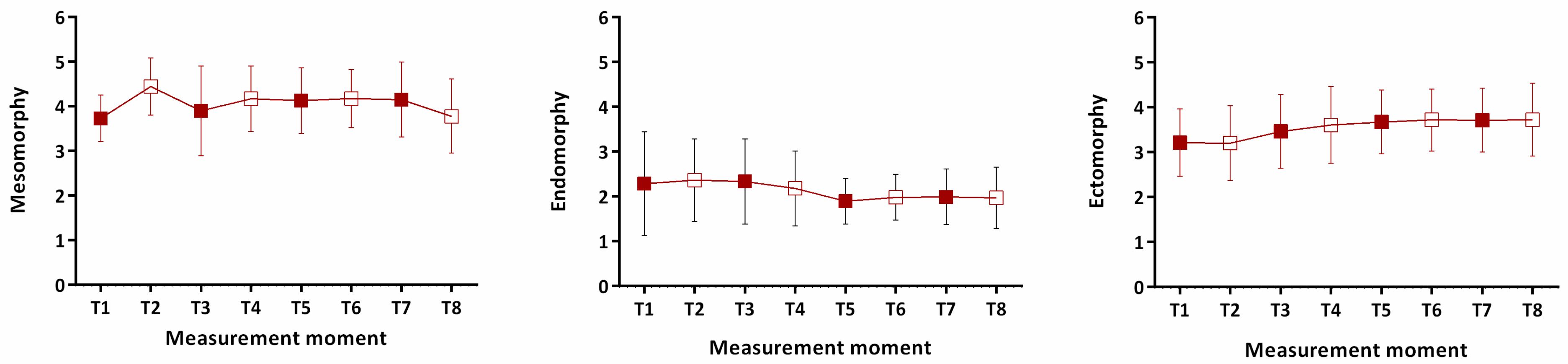


Figure 4.3.16. Mean values in somatotype at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation.

4.3.3.2. Physical performance

Mean measures of physical performance tests are shown by measurement moment for all players in Table 4.3.6 and Figures 4.3.17 and 4.3.18. Overall, performance variables showed much greater variability in the magnitude of the change when compared to changes in anthropometry, body composition and somatotype.

In the velocity 15-m test (Figure 4.3.19) significant differences were observed across seasons ($p<0.001$). Initially, in the youngest ages, percentage changes ranged from 0.47 ± 3.05 % to 1.25 ± 4.52 %. Thus, a small but continuous improvement was observed. Nevertheless, the main difference in the percentage change in velocity 15-m happened in the U13 and U14 seasons, were two improvement peaks were detected (8.04 ± 9.89 % and 10.22 ± 8.09 %, correspondingly).

Significant differences between seasons were observed in the agility test ($p< 0.001$) (Figure 4.3.20). Overall, the percentage of change decreased with age. In fact, the highest value of percentage change was observed in the U11 season (3.65 ± 2.85 %). It is worth noting that similar to what happened in the velocity test, there were two improvement peaks in the U13 and the U14 seasons (2.82 ± 1.84 % and 2.61 ± 3.09 %, respectively).

As it can be observed in Figure 4.3.21, significant differences were detected across seasons in Yo-Yo IR1 ($p< 0.001$). Largely, a decrement of percentage change was observed in all the off-seasons when compared to their consecutive seasons. In addition, two improvement peaks were observed in the U13 and the U14 seasons (30.76 ± 32.13 % and 51.06 ± 31.81 %, respectively). Precisely, this is line with the results obtained in the previous two tests, velocity 15-m and agility tests.

Results of CMJ are shown in Figure 4.3.22. There were significant differences in CMJ among seasons ($p< 0.001$). Surprisingly, there was a decrement of performance in the CMJ test in the U11 season (-11.18 ± 7.44 %). Afterwards, a general trend to improve was detected even if, as it happened in the rest of the tests, the mean change percentage decreases in the off-seasons. The highest percentage change was observed in the U14 season (8.13 ± 6.19 %).

Regarding dynamometry, significant differences among seasons are shown in Figure 4.3.23. However, the variability in the change of percentage was greater than in other performance variables. Also, it is interesting to note that, while the higher mean change value was observed between the end of the U11 season and the beginning of the U12 season (26.06 ± 15.48 %), there was a significant decrement in the U12 season (-7.00 ± 24.51 %).

Table 4.3.6. Mean physical performance tests classified according to the measurement moment (± SD).

	U11				U12				U13				U14			
	T1		T2		T3		T4		T5		T6		T7		T8	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Velocity (m/s)	23	5.92 (0.25)	23	5.95 (0.24)	46	5.94 (0.24)	46	6.08 (0.25)	37	6.22 (0.27)	37	6.74 (0.56)	27	6.49 (0.33)	27	7.14 (0.53)
Agility (m/s)	23	2.00 (0.07)	23	2.07 (0.06)	46	2.09 (0.08)	46	2.13 (0.08)	37	2.17 (0.08)	37	2.24 (0.07)	27	2.21 (0.09)	27	2.26 (0.07)
Yo-Yo IR1 (m)	19	675.79 (178.34)	19	950.00 (215.94)	28	1040.00 (315.44)	28	1097.14 (315.60)	31	1155.56 (241.11)	31	1449.03 (257.52)	27	1368.24 (307.13)	27	2041.43 (268.77)
CMJ (cm)	23	34.37 (4.42)	23	30.37 (4.23)	46	32.63 (4.66)	46	32.55 (4.40)	37	34.18 (4.26)	37	35.51 (4.55)	27	37.90 (4.34)	27	40.92 (4.26)
Dynamometry (kp)	23	16.31 (2.71)	23	19.80 (3.64)	46	24.89 (3.84)	46	23.15 (6.91)	37	27.08 (4.52)	37	27.81 (5.62)	27	31.28 (5.96)	27	36.97 (5.98)

Velocity: velocity 15-m test; Agility: barrow agility test; Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1): CMJ: counter-movement jump; Dynamometry: hand dynamometry.

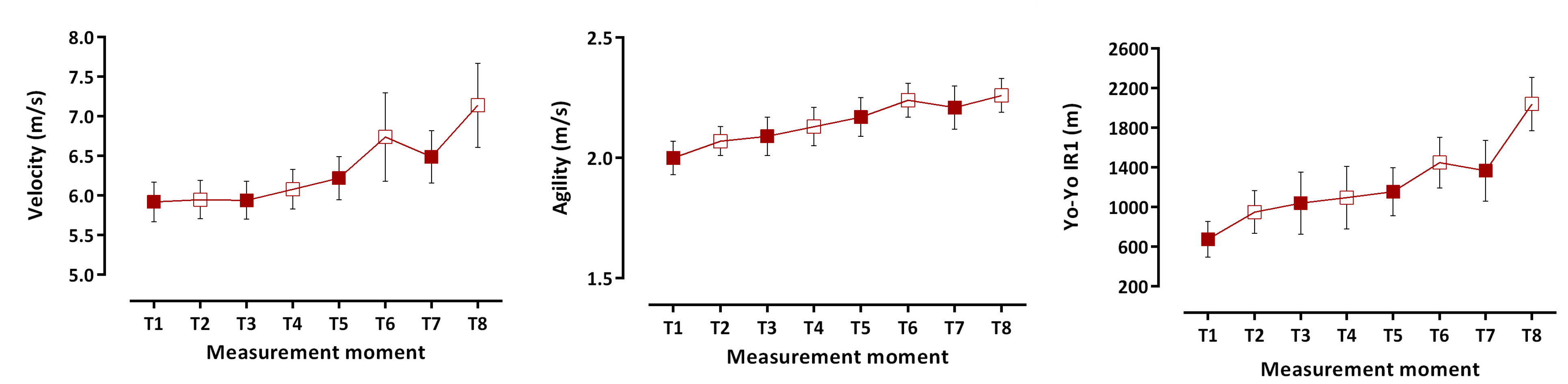


Figure 4.3.17. Mean values in velocity, agility and Yo-Yo IR1 at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation.

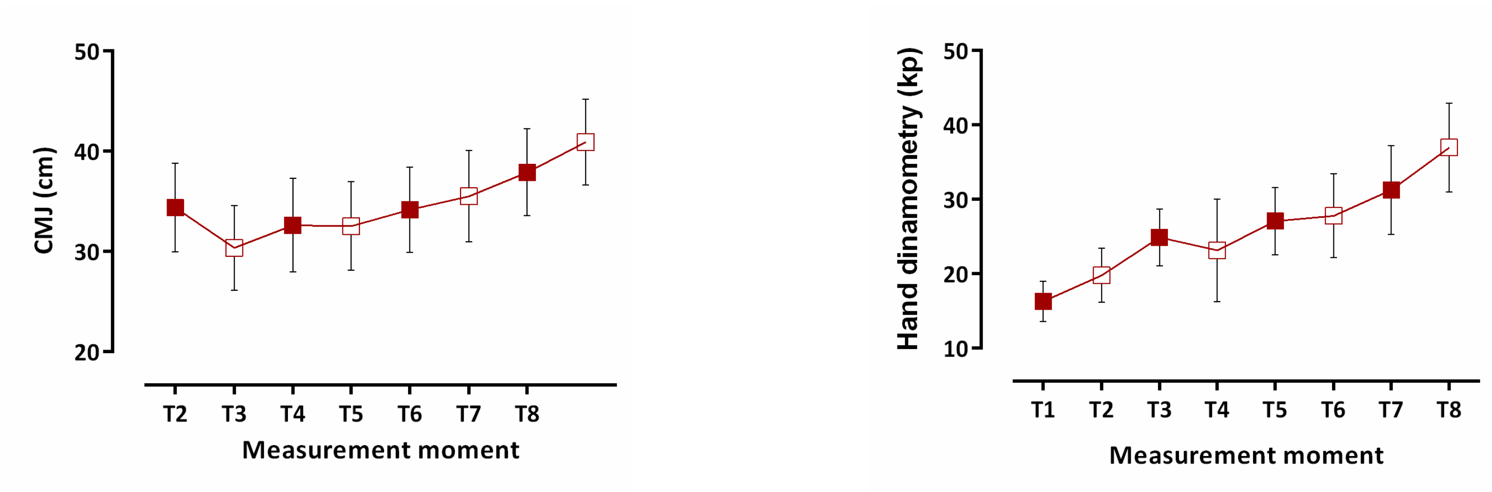


Figure 4.3.18. Mean values in velocity, agility and Yo-Yo IR1 at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation

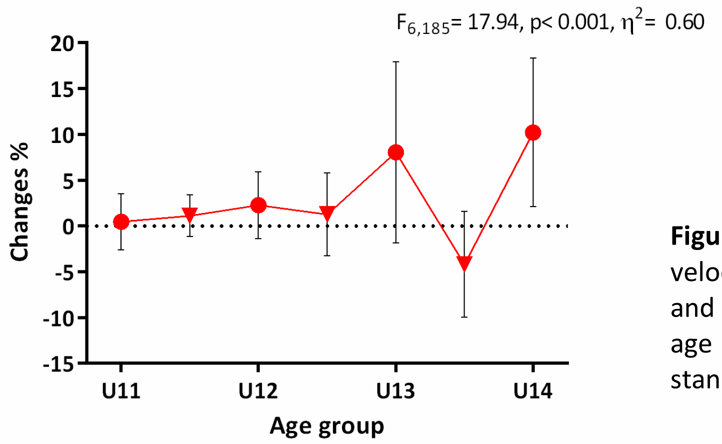


Figure 4.3.19. Percentage changes in velocity 15-m during the seasons (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

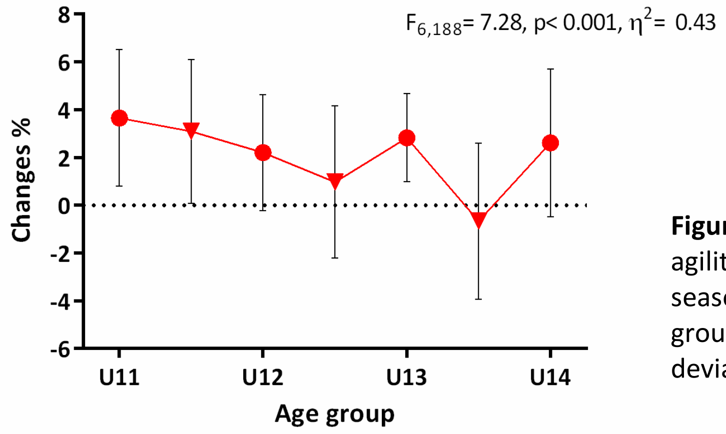


Figure 4.3.20. Percentage changes in agility during the seasons (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

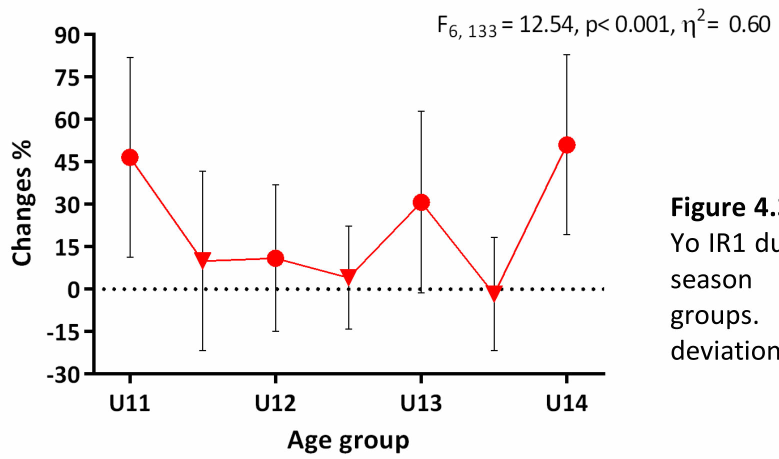


Figure 4.3.21. Percentage changes in Yo-Yo IR1 during the seasons (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

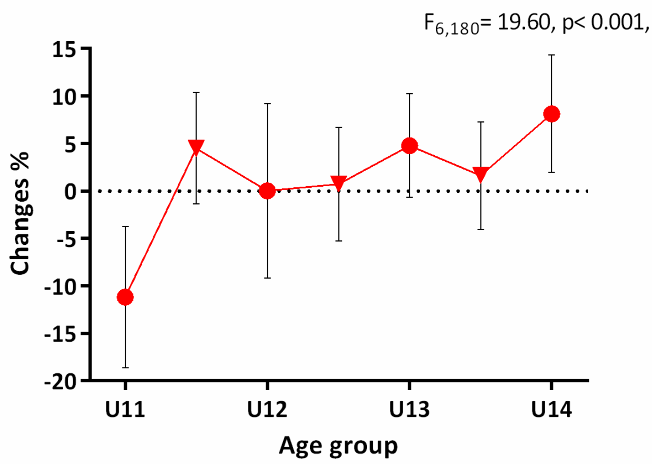


Figure 4.3.22. Percentage changes in CMJ during the seasons (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

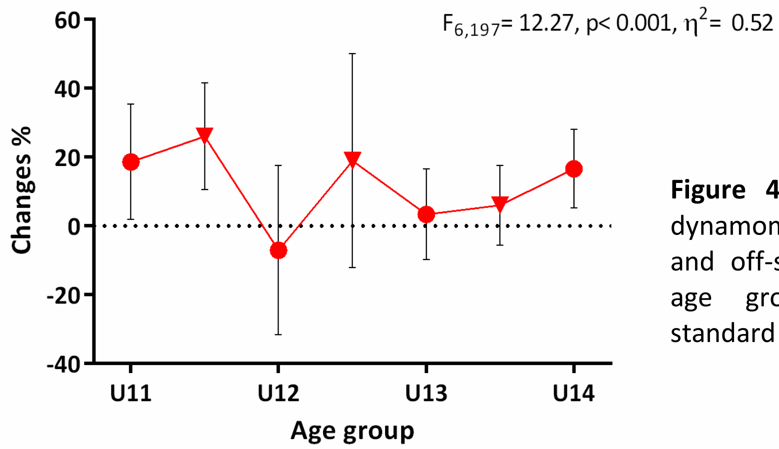


Figure 4.3.23. Percentage changes in dynamometry during the seasons (dots) and off-season (triangles) for different age groups. Error bars represent standard deviation.

4.3.3.3. Maturation

Mean measures of salivary hormones concentration are shown by measurement moment for all players in Table 4.3.7 and Figure 4.3.26. As mentioned before in the study design, salivary samples were collected twice during each season with exception of the first season, where samples were only collected at the beginning of the season. Thus, the percentage changes that correspond to the U11 season happened during the time interval of approximately 12 months (instead of 9 months).

In regard to testosterone, non-significant differences were observed between seasons. in percentage changes (Figure 4.3.24). Although levels of testosterone increased with age during the four seasons and percentage changes were positive, changes tend to diminish with increasing age.

Similar to what happened with testosterone, although levels of DHEA increased with age non-significant differences were observed among seasons (Figure 4.3.25). Most of the percentage changes were positive and standard deviations were large. Interestingly, percentage changes were larger during the seasons when compared with changes off-seasons.

Table 4.3.7. Mean salivary hormones concentration classified according to the measurement moment (± SD).

	U11				U12				U13				U14			
	T1		T2		T3		T4		T5		T6		T7		T8	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Testosterone (pg/ml)	27	19.24 (17.55)	-	-	40	20.94 (13.22)	40	22.56 (12.41)	35	41.68 (20.48)	35	49.34 (19.08)	21	58.02 (22.34)	21	64.21 (20.61)
DHEA (ng/ml)	27	2.94 (2.28)	-	-	32	5.13 (3.95)	32	5.99 (3.55)	36	4.36 (2.24)	36	7.78 (2.75)	25	7.57 (6.44)	25	7.41 (4.61)

DHEA: dehidroepiandrosterone.

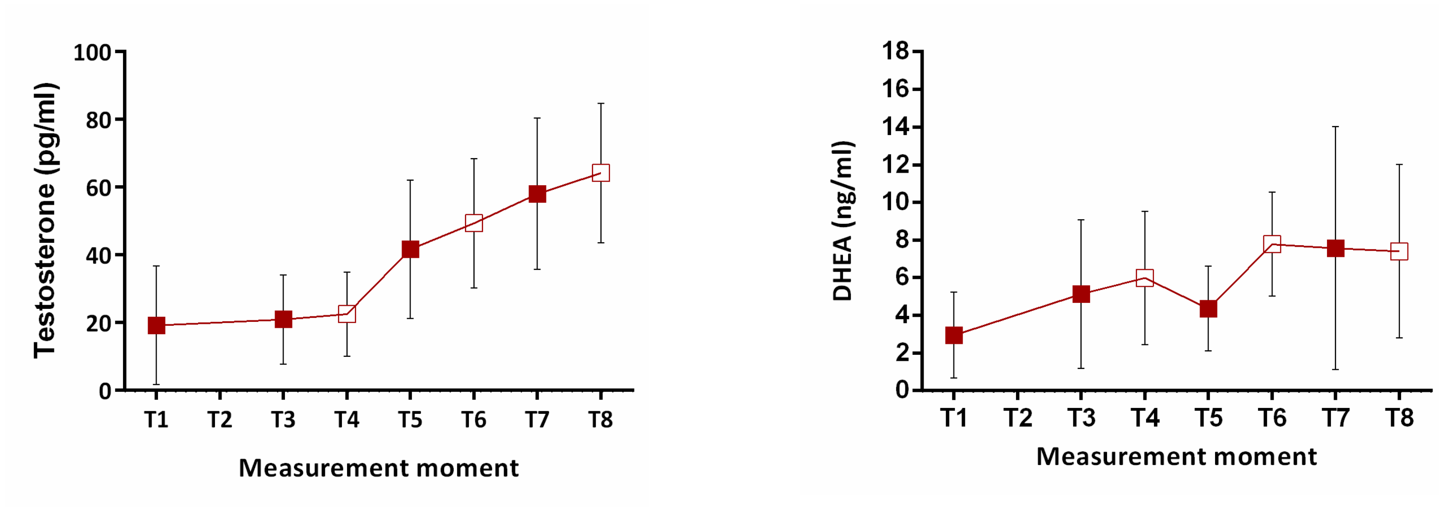


Figure 4.3.26. Mean values in testosterone and DHEA at the beginning (filled squares) and at the end (open squares) of the different seasons. Error bars represent standard deviation.

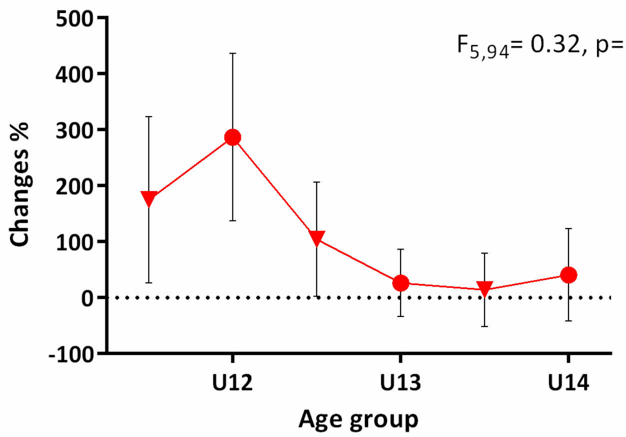


Figure 4.3.24. Percentage changes in testosterone during the seasons (dots) and off-seasons (triangles) for different age groups. Error bars represent standard deviation.

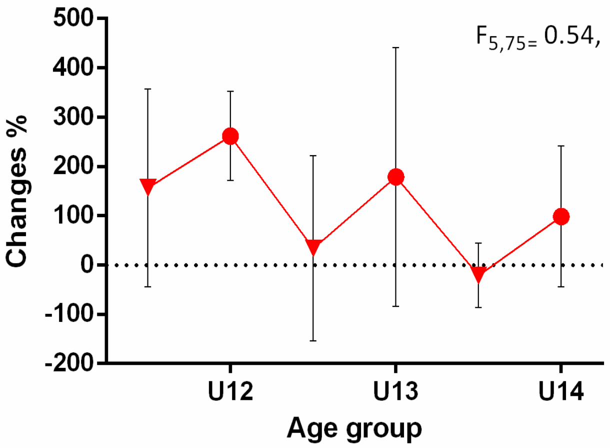


Figure 4.3.25. Percentage changes in DHEA during the seasons (dots) and off seasons (triangles) for different age groups. Error bars represent standard deviation.

4.3.4. Discussion

Although longitudinal data exists for changes in development in general population (Hernandez et al., 1988; Malina, Bouchard, & Bar-Or, 2004), there is limited information with regards to youths involved in systematic training. Moreover, little has been written regarding elite youth soccer players involved in youth academies. Thus, the present study offers further insights into the changes in anthropometry, physical performance and maturation in young soccer players engaged in a professional soccer club developmental program during 4 years.

4.3.4.1. Anthropometry, body composition and somatotype

As expected, our results showed significant increases in height and body mass as age increased. However, although all tissues, organs and systems of the body mature with growth, they do so at different times and rates (Meylan, Cronin, Oliver, & Hughes, 2010). In line with this statement, the rate of changes observed in anthropometry, body composition and somatotype changed throughout the follow-up.

Specifically, changes in height and body mass were significantly higher in the U13 and the U14 seasons. On the one hand, previous studies have reported that peak weight velocity appears to occur closer to age at height velocity in boys. Moreover, observations in North African and European boys indicated that PHV vary between 13.3 and 14.4 years (Malina, Bouchard, & Bar-Or, 2004). On the other hand, literature indicates that the major changes in size and physical body composition occurs among boys between the ages of 9 and 16 years old due to increases in hormonal secretion (Bloomfield, Polman, Butterly, & O'Donoghue, 2005; Malina, Bouchard, & Bar-Or, 2004). Thus, it seems logical to suggest that the significant peak in percentage changes observed in weight and height may be related to a growth spurt occurred in players aged 13-14 years old. Noteworthy, the decrement observed in the rate of change in height and body mass between U13 and the U14 seasons. Nonetheless, it is important to note that, whereas the period of time corresponding to the season is 9 months, the off-seasons period is barely of 4 months. Thus, it is logical to conclude that changes during a shorter time may be smaller than those observed during a larger interlude.

Also, significant differences were observed in the rate of growth in sitting height and leg length. Changes observed in sitting height were similar to those observed in height, whereas the greatest differences in leg length were observed in the U11 and the U12 seasons (2.51 ± 3.90 % and 2.45 ± 2.37 %, respectively) confirming that in the pre-pubertal year's growth occurs more in the limbs than in the trunk (Malina, Bouchard, & Bar-Or, 2004). Therefore, the positive change observed in height may be mainly due to the increase in leg length rather than in trunk length (Fredriks, van Buuren, Fekkes, Verloove-Vanhorick, & Wit, 2005).

Correspondingly, the opposite occurs in the U14 season: sitting height change increases while leg length change decreases. Overall, these results reinforce the idea that growth in leg length terminates earlier than growth in sitting height or trunk length, which continues into late adolescence (Malina, Bouchard, & Bar-Or, 2004).

Regarding BMI, although the findings of the current study indicated that BMI increased with age through adolescence and are in agreement with those reported in similar studies (Malina, Bouchard, & Bar-Or, 2004; Nikolaidis & Vassilios Karydis, 2011), non-significant differences in the magnitude of change were observed across the different age groups. Taking into account that BMI in children and adolescents is more an indicator of heaviness and indirectly of fat (Nikolaidis, 2012a), these results corroborate the notion that players get taller and heavier as age increases regardless of what happens in both the fat and the lean components of body composition. Certainly, the interpretation of BMI in children and adolescents as an indicator of fat adiposity needs care because an elevated BMI in this population is not necessarily indicative of excess of fat adiposity (Malina, Bouchard, & Bar-Or, 2004; Ricardo & Araujo, 2002).

Within the methods used to diagnose the excess of fatness, the skinfold measure has been widely used to estimate overweight and obesity in children and adolescents (Gil et al., 2010) and in youth soccer players (Gil, Ruiz, et al., 2007; Nikolaidis 2012b). Our results demonstrate that the subcutaneous fat distribution during growth of the soccer players of the present study followed the trend observed in the general population: trunk skinfolds increase significantly during the 13 years of age and decline slightly through 14 years, whereas extremity skinfold increase to about 11 to 12 years of age and then decline until 15 to 16 years (Malina, Bouchard, & Bar-Or, 2004).

Regarding somatotype, analysis revealed that players ectomorphy was stable during the follow-up in agreement with the notion that ectomorphy is greater in children than in adults (Malina et al., 1997). However, a tendency was observed for endomorphy to decrease with age. Specifically, a more marked decrement was identified in the beginning of the U13 season (T5). Other studies had already demonstrated that this variation is probably biological and has something to do with maturation (Malina, Eisennman, et al., 2004). Indeed, during the growth spurt, boys experience a rather marked increase in muscle mass and a decrease in subcutaneous tissue. Similarly, mesomorphy values increased with age. These results are probably associated with the aforementioned increase in muscle mass related to maturation.

4.3.4.2. Physical performance

In general terms, there were significant increases in all the performance tests with age. Namely, as players become older they get better outcomes in the tests confirming results of previous authors in that performance characteristics improve with age (Le Gall et al., 2010; Mirkov et al., 2010). However, the magnitude of the improvement in the present study appears to be different indicating performance spurts (e.g., speed, power, endurance) that may occur at different moments depending on the maturation tempo and timing of the players (Meylan et al., 2010).

With regards to the velocity test, when analyzing percentage changes, the annual development of less than 4 % appeared to be somewhat lower when compared with the 5 % of average annual development presented in young elite soccer players by other authors (Le Gall et al., 2010; Vaeyens et al., 2006; Vänttinen, Blomqvist, Luhtanen, & Häkkinen, 2010). Moreover, throughout the follow-up performance appears to be quite stable during the youngest age groups and presented increases thereafter. However, a peak of development in sprinting speed was observed between U13 and U14 seasons, which is in agreement with the results observed for both general population and youth soccer players (Malina, Bouchard, & Bar-Or, 2004; Philippaerts et al., 2006; Vänttinen et al., 2010).

Thus, the increase in velocity observed in that period may be related to adolescent spurts in body dimension that occurs on average shortly before peak height velocity (Beunen & Malina, 1988; Malina, Bouchard, & Bar-Or, 2004). Nevertheless, the improvements observed in the change in sprint performance, from being relatively slow at the youngest age to be relatively fast at the oldest age, may also reflect a selection bias towards more mature and physically developed players (Malina, Cumming, Kontos, et al., 2005).

Although the results of the agility test used in the current study may be difficult to compare and interpret due to a lack of standardization of testing procedures in literature, our results showed that the highest change rates happened in the U11 season and, afterwards, the rates seem to plateau. This is in agreement with observations of other authors that suggest that the fastest development in agility occurs during pre-puberty (Malina, Bouchard, & Bar-Or, 2004) and that the magnitude of improvement in agility may be influenced by the training status or age of the players, as younger individuals have demonstrated greater agility enhancement than adults (Sheppard & Young, 2006). Nonetheless, considering that players who entered the club at the U11 season have never done the agility protocol before, it is reasonable to think that, since the test is often used in the soccer academy, the learning of a new complex testing procedure during the season may have influenced to a larger improvement regardless of any previous capacity to move and change directions.

In addition, a second peak of improvement was observed in the U13 season. Agility has been defined as a result of a number of neurophysiological factors and it is difficult to determine exactly which factors contribute to a changed result (Buttifant et al., 2002). However, evidence drawn from longitudinal data in youth soccer players showed gains in agility, on average, close to the time of peak height velocity (Philippaerts et al., 2006).

Hence, the peak of improvement observed may be partially attributed to linear growth and gains in muscle mass with pubertal growth. This is in line with previous studies that suggest that annual improvement in agility is rather modest during adolescence mainly because the fastest development in agility occurs during pre-puberty, after which the improvement slows down during adolescence to reach the final level at early adulthood (Malina, Bouchard, & Bar-Or, 2004).

The large improvements in Yo-Yo IR1 performance from 10 to 14 years of age confirms the observations that the level of performance progresses with a corresponding increase with age based on cross-sectional data (Deprez et al., 2012; Krustrup et al., 2006). However, results indicated significant differences between the rates of improvement during the follow-up. Thus, the development of performance appeared to be more pronounced in the U11, U13 and U14 seasons whereas the improvement were smaller in all the off-seasons as well as the U12 season. Considering that in all the off-season measurements the changes tend to decrease, we may assume that the development of the Yo-Yo IR1 may be positively influenced by systematic training exposure and, therefore, results might be smaller because of the lack of training during the summer vacation. This finding is in agreement with Krustrup et al. (2010) that suggested that soccer training improves greatly the general working capacity of young persons. Similarly, it supports the idea that soccer-specific training over the season in adolescent years may affect positively intermittent endurance training (Hammami et al., 2013). Altogether, it seems logical to conclude that improvements observed in the U11 season may be larger due to the specific intermittent endurance training that players received when they entered the club. However, as noted above, the development of performance also appeared to be more pronounced in the U13 and U14 seasons. Previous research has shown that these improvements may be a contribution of the growth spurt related to the increases in body dimensions and muscle mass that need to be considered in the context of changes associated with growth and maturation (Armstrong et al., 1999; Beunen et al., 2002; Geithner et al., 2004; Mujika, Spencer, et al., 2009; Nevill, Holder, Baxter-Jones, Round, & Jones, 1998).

It has been well documented that the counter-movement jump is a reliable test for evaluating the explosive strength in the lower limb (Chamari et al., 2008). Nevertheless, comparisons to previous vertical jump data are difficult given the lack of standardization in jump protocols. However, the trend of improvement in counter-movement jump with age observed in our study is consistent with longitudinal observations in youth soccer players (Nikolaidis, 2014; Williams et al., 2011). On the one hand, it is important to note that there was an evident decrement in the performance during the U11 season. These results are consistent with observations by Ferrete, Requena, Suarez-Arrones, & Sáez de Villarreal (2014) in pre pubertal soccer players aged 8 to 9 years. In the aforementioned study, the performance in jump test of players undertaking usual soccer training decrease whereas an experimental group exposed to additional specific combined strength and high intensity training had an increase around 7 %. Another possible explanation for the observed decrease in counter-movement jump may be related to a temporary decline in performance that has been attributed to disrupting motor coordination during periods of accelerated growth and that has been reported elsewhere (Philippaerts et al., 2006; Williams et al., 2011). Moreover, this suggestion is supported by the accelerated growth observed in the lower limbs relative to the trunk during the U11 and the U12 seasons.

The aforementioned results indicated that peak gains in counter-movement jump performance attain maximal development at the age of around 13 years, coincident with peak height velocity (Philippaerts et al., 2006). This is in agreement with observations in Spanish young soccer players with a similar age range as the present study sample (10 to 14 years of age) (Gravina et al., 2008). Moreover, previous research has demonstrated that an increase in leg length and muscle power should be expected during growth independently from the stimulus of soccer training. Consequently, we may conclude that overall jump performance increases clearly due to pubertal changes more than for soccer specific training (Vänttinen et al., 2011).

Together, the small improvements observed over the four seasons suggest that stimulation of jumping in soccer training may be limited to promote jumping ability during pubertal years in soccer players (Michailidis et al., 2013). Consequently, coaches may need to consider alternative training, like plyometrics, to promote the development of jumping in soccer (Sedano, Matheu, Redondo, & Cuadrado, 2011; Thomas, French, & Hayes, 2009).

In regard to handgrip, data for the general population of adolescent males suggested that linear increases in handgrip occur up to ages 13-14 after which the development of handgrip accelerates in boys (Cohen et al., 2010). Correspondingly, the results observed in our study indicated differences in the rate of improvements during the follow-up. Firstly, a small decrease in the rate of improvements was observed in the U12 season. Similar results were observed in a study carried with English school children by Cohen et al. (2010) that observed a large drop in English boys' handgrip compared with the reference Swedish data between ages 12 and 13 years old. Secondly, an increase in the change of performance was observed in the U14 season that may be related to peak gains in handgrip that are coincident with peak height velocity and that are probably related to the adolescent spurt in muscle mass that occurs shortly after peak height velocity (Butterfield, Lehnhard, Loovis, Coladarci, & Saucier, 2009; Philippaerts et al., 2006). In this regard, other authors have reported that soccer player's strength development is closely related to the hormonal maturity that happens during puberty as muscle during growth is mainly determined by hormonal environment (Hansen et al., 1999; Le Gall et al., 2010; Vänttinen et al., 2011).

Comparisons to previous handgrip data merits caution because of the lack of relevant developmental norms for the grip strength in children (Häger-Ross & Rösblad, 2002). Furthermore, differences in the type of dynamometer used could also contribute to the variability in reported handgrip values, as well as the use of hand size adjustments, the variations in the protocol used for measurement and the method of reporting scores (Ploegmakers, Hepping, Geertzen, Bulstra, & Stevens, 2013).

When analyzing more closely the off-season periods, an evident decrease in performance was observed in the U13 off-season (between U13 and U14 seasons) in the velocity 15-m test, the agility test and the Yo-Yo IR1 (Figures 4.3.19, 4.3.20 and 4.3.21, respectively). Although this decrease was not observed in the CMJ, when we analyzed the percentage of changes we found that there was a significant decrease in the change of the improvements in all the physical performance tests, including CMJ, precisely in this measurement point.

This finding may be explained by the concept of detraining. Indeed, detraining is a partial or total physiological loss of training adaptations, due to training reduction or suspension (Mujika & Padilla, 2001). When the period of detraining is longer than four weeks is considered a long-detraining (Mujika & Padilla, 2000). Thus, we may consider the off-season periods of the present study as long-detraining periods. Melchiorri et al., (2014) reported that, in a sample of young soccer players aged 15 years old, performance undergoes a significant decline after periods of long-term detraining. In contrast, in our study, improvements were observed in most of the off-season periods except for a decrease observed in some of the tests in the U13 off-season. Several hypotheses may explain these findings. On the one hand, the improvements observed in the youngest off-season periods may be associated to improvements related to growth and maturation. On the other hand, another hypothesis may be connected to activeness of children during the summer. Indeed, as children grow they tend to be less active and, therefore, the effect of detraining may be more accentuated. Finally, another possible explanation for the results observed may be in line with results obtained by other authors that demonstrated that whereas well-trained athletes performance decrease after a long detraining period (Koundourakis et al., 2014) in less trained athletes variations are not so evident (Coyle et al., 1984).

It is well known that elite soccer players, as they grow up, receive a more specific training. Therefore, in our study, the detraining may be more relevant in the U13 off-season because the training level reached is higher at the end of the previous season. As such, it would be interesting for further research to analyze what happens in the off-seasons in older categories for a better and a complete understanding of the detraining phenomenon during adolescence.

4.3.4.3. Maturation

Literature indicates that the major changes in size, physical body composition and motor skills occur among boys between the ages of 10 and 16 years old (Bloomfield et al., 2005; Malina, Bouchard, & Bar-Or, 2004) due to increases in hormonal secretion. Although the role of hormonal status in influencing youth athletic performances is receiving increasing attention, scarce data are available on changes occurred during puberty in a highly selected group of youth soccer players.

Whilst the data obtained in our study revealed a significant main effect for age in both hormones supporting findings in previous studies (Di Luigi et al., 2006; Durdiaková et al., 2013), significant differences were not observed among the percentage changes. Interestingly, a great variability was observed in the rate of changes in both hormones revealing considerable inter-individual differences between the players. These results corroborate the notion that the adolescent growth spurt varies considerably in timing and duration among individuals and, therefore, inter-individual variability of certain parameters (pubertal stage, testosterone concentrations, etc.) may be found within players of the same chronological age (Baldari et al., 2009; Di Luigi et al., 2006; Moreira et al., 2013). Moreover, this variability may be aligned with the lack of statistical significance observed among the changes in improvement.

In relation to testosterone, the possible explanation for the lack of differences in changes across the follow-up may be related to incomplete sexual maturation in the assessed soccer players. Indeed, testosterone does not significantly increase between Tanner stages 1 and 2, but it significantly increases after stage 2 until stage 5 (Hansen et al., 1999). Although results were not significant, the major rate of change was observed in the U12 season and, afterwards, changes tend to diminish with age. Thus, our results corroborate a well-known pattern that indicates that a minor increase happens in testosterone just before puberty (Malina, Bouchard, & Bar-Or, 2004; Vänttinen et al., 2011).

Regarding DHEA, changes were larger in the U12 season in contrast to previous studies in which a peak in DHEA concentration at 13 years old was reported (Papacosta et al., 2010). Interestingly, rates of improvement were larger during seasons than during off-seasons. In this regard, little has been investigated concerning the effect of physical exercise on DHEA and the literature reports conflicting results (Binello & Gordon, 2003; Corrigan, 1999; Thomasson et al., 2010). Nonetheless, in agreement with our results, Keizer, Janssen, Menheere and Kranenburg (1989) found that exercise produced a significant rise in DHEA levels in trained sportsmen and, similarly, Cadore et al. (2008) showed a significant increase in DHEA in response to a resistance exercise in healthy men.

Caution is necessary when interpreting and comparing the results of the levels of hormone concentration in the present study given the aforementioned large differences between individuals. Furthermore, as the daily rhythm of testosterone and DHEA is associated with higher levels in the morning (Di Luigi et al., 2006; Whetzel & Klein, 2010), we cannot exclude the possibility that our results might have been different if the evaluations had been performed during the morning. Nevertheless, all the samples were taken at the same time of the day on all players and all the testing conditions were standardized including hydration and pre-assessment food intake.

4.4.5. Conclusion

In summary, the results indicate that the anthropometrical and physical performance characteristics of the present sample of elite youth soccer players changed significantly during the 4 year follow-up. Moreover, rates of seasonal changes were observed in body size, in body proportion, body composition and physical performance confirming that the improvements of physical capacities undergoes periods of accelerated development. Also, an evident decrement in performance was observed in most of the analyzed tests in the U13 off-season indicating a possible effect of detraining at this age. Altogether, this information can be valuable to coaches and technical staff by providing them with a better understanding of expected changes during this period. Specifically, this information about growth can improve insight into the development of a specific group and can assist in an appropriate talent development program design. Nonetheless, further research including late adolescent players might be necessary to obtain a more complete developmental growth profile of elite youth soccer players.

CHAPTER 4

YOUTH SOCCER PLAYERS WHO ENTER, CONTINUE AND DROP-OUT THE YOUTH ACADEMY OF THE ATHLETIC CLUB

4.4. CHAPTER 4

4.4.1. Introduction

Nowadays, the role of the youth academies is vital in the long-term development of young soccer players. In fact, the role of the clubs academies is to act as centers for selection and development of future successful elite soccer players (Hammami et al., 2013). In this regard, coaches are continuously searching for the most successful method for identifying and developing talented young players that will progress to professional level (Le Gall et al., 2010; Stratton et al., 2005).

In the attempt to perform an objective evaluation of the young soccer players' potential, the anthropometrical and physical profile results are of interest (Hammami et al., 2013). Actually, such assessments are considered valuable in the determining a player´s chance of proceeding to a higher level of achievement (Vandendriessche et al., 2012). In order to investigate witch factors influence in the progression of young soccer players, studies on talent identification and selection have been conducted between elite, sub-elite and/or non-elite youth players (Hansen et al., 1999; Malina, Ribeiro, et al., 2007; Reilly, Bangsbo, & Franks, 2000). Thus, studies have revealed that height, sprint time, ego orientation and anticipation skill were the most discriminating variables between young players of different competitive levels (Malina, Eisennman, et al., 2004; McMillan, Helgerud, Macdonald, & Hoff, 2005). However, little information is available on already selected elite players exposed to systematic training. Moreover, potentially unique characteristics of players who were successful or unsuccessful in progressing to a higher level within a talent identification program have not been previously reported.

Most of the mentioned studies tend to focus on adolescent players as talent identification programs are traditionally conducted during adolescence and players are often selected at a very young age (Gravina et al., 2008). During adolescence, players suffer a considerable variation in size and biological maturation. As such, growth and maturation are considered to be the main confounders in the prediction of future performance (Vandendriessche et al., 2012). Maturation has been identified as a significant contributor to aerobic fitness (Carvalho et al., 2011), anaerobic power (Carvalho et al., 2013), explosive power, sprinting (Malina, Eisennman, et al., 2004) and change of direction (Vaeyens et al., 2006). Moreover, the role of maturation in soccer appears to be important in the selection process, as it systematically excludes late maturing boys and favors average and early maturing boys as chronological age and sport specialization increase (Malina et al., 2000). Consequently, any talent identification process must acknowledge and account for maturity-related variation in performance.

Related to maturation, the relative age effect (RAE) is a phenomenon whereby youth who are born in the selection year are routinely selected ahead of those born later in the year (Lloyd et al., 2014). The presence of RAE has been widely reported and studied in relation to a large number of cultural contexts and sports such as baseball, ice-hockey, netball, rugby, soccer or tennis revealing skewed birth-date distributions favoring individuals born early in the selection year (Barnsley, Thompson, & Barnsley, 1985; Musch & Grondin, 2001; Wattie et al., 2008). Specifically soccer is characterized by a significant over-representation of players born in the early part of the selection year. Accordingly, there is an extensive body of recent literature showing that children born earlier in age-based category are more likely than children born more lately to access higher levels of competition or professional ranks (Musch & Grondin, 2001). This differentiated access to high-level training is considered as a kind of discrimination because it disadvantages players born late after the cutoff date reducing their chances to access to the elite level (Delorme, Boiché, & Raspaud, 2010; Deprez et al., 2012; Musch & Hay, 1999). Such a selection bias happens because of the older children possessing greater size, strength, and speed (Gil et al., 2014).

Elite adolescent players within a sport, specially soccer, are often relatively homogeneous in training history, functional capacity and sport-specific skills (Malina, 1994). This homogeneity makes it even more difficult for coaches and training staff to evaluate which factors influences the progression of the young players. As such, there is a need to identify in the elite level the differences between the players who achieve to progress to higher categories (continue) and the ones that are unsuccessful in progress (drop-out). Thus, the purpose of the present study was to use a mixed-longitudinal approach to establish distinguishing characteristics of expertise and to identify the factors that determine player´s potential to progress to higher levels within an elite youth soccer academy.

4.4.2. Methodology

Study design

The present study involves a mixed-longitudinal analysis of the continuity of young soccer players among different age groups of the Athletic Club during the seasons 2009-2010 to 2012-2013. Thus, data was collected over a total of four seasons, with new players joining the club at the beginning of each season, players progressing to the next age category within the club and players leaving the club at the end of each season (Figure 4.4.1).

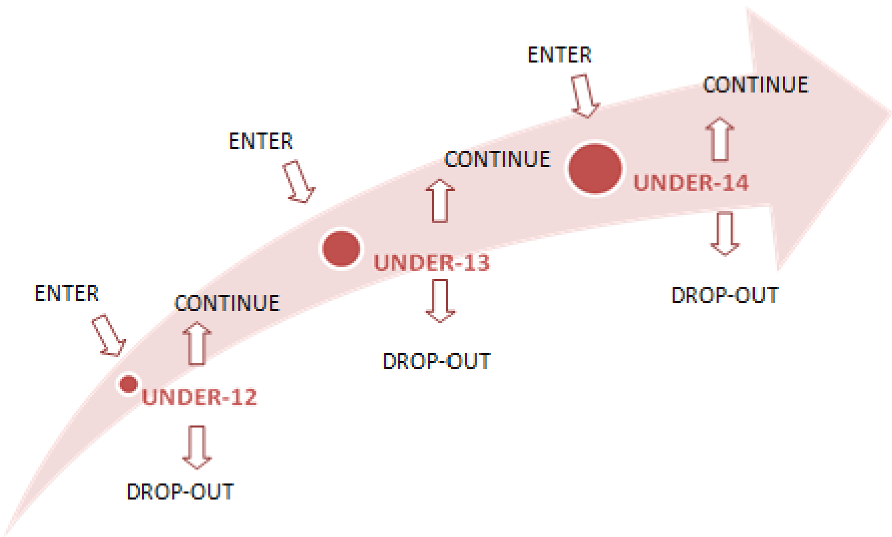


Figure 4.4.1. Diagram of the players that enter, continued and dropped-out the club.

The study adopted a repeated measures design, with pre- and post-season measurements during the training-season: first, at the start of the season (end of September- beginning of October); second, the end period of the training-season (end of May- beginning of June). Therefore, only players with results for consecutive test sessions were included in each age group. The following measurements were taken: anthropometry (height, body mass, sitting height, 6 skinfolds (tricipital, subescapular, suprailiacal, abdominal, thigh and leg) and physical performance tests (velocity 15-m (velocity), barrow agility test (agility), Yo-Yo intermittent recovery test (level 1) (Yo-Yo IR1), counter-movement jump (CMJ) and hand dynamometry (dynamometry). Also, chronological age (CA) and age at peak height velocity (APHV) were calculated in each measurement moment. Players were measured and tested annually within a 2-week period and testing took place at the same place and time of the day in the same external conditions.

For encoding data to analyze birth distribution, the selection year corresponded with the regular calendar year that started January 1st and ended December 31st of the same year. Firstly, the date of birth of the participants was divided in two semesters: semester 1= 1st January to 30th June; semester 2= 1st July to 31st December. Also, the date of birth was divided in four quarters: quarter 1= 1st January to 31st March; quarter 2= 1st April to 30th June; quarter 3= 1st July to 30th September; quarter 4= 1st October to 31st December.

Sample

The sample included 155 players who were part of the Athletic Club youth academy between seasons 2009-2010 and 2012-2013. Players were divided in 3 different age groups: players from Under-12 (U12), Under-13 (U13) and Under-14 (U14) age groups. Within these age groups, three groups were defined:

- Club players: players who continued to train at the same club and, therefore, progressed to the next age category.
- Drop-out players: players who discontinued (abandoned) the club.
- Enter players: players who were selected to enter the club at the beginning of each season.

Table 4.4.1. Sample of players that entered, continued and dropped out the club according to their age group (number of players).

	Club	Drop-out	Enter	Total
U12	36	19	6	61
U13	29	13	8	50
U14	25	12	7	44
Total	90	44	21	155

Statistical Analysis

Descriptive statistics for all measures in each age group are presented as mean ± standard deviation. All variables used in the study were checked for normality of distribution before the analyses, Kolmogorov-Smirnov tests were used for each variable. A two way repeated measures analysis of variance (ANOVA) was performed to determine if significant differences existed between groups (firstly, Club *vs.* Drop-out; secondly, Club *vs.* Enter) and testing (T0 and T1). To determine the differences between interactions the magnitude of the differences or μ^2 was calculated according to Cohen (1988) and interpreted as small (> 0.01 and < 0.06), moderate (≥ 0.6 and < 0.14) and large (≥ 0.14).

4.4.3. Results

4.4.3.1. Club players vs. Drop-out players

4.4.3.1.1. UNDER-12 AGE GROUP

Anthropometry, body composition and somatotype

Table 4.4.2 summarizes the means of anthropometric characteristics, at the beginning and at the end of the soccer season of the two groups of players of the U12 teams: Club players and Drop-out players. Analysis revealed a significant main effect of time in both groups in height, weight and leg length ($p< 0.001$) and in sitting height in the club players ($p< 0.01$). No effect of group or interaction was observed. However, Club players were slightly lighter, had longer leg length and smaller BMI than the Drop-out players.

Regarding circumferences, non-significant differences in time, group or interaction were observed. Similarly, in the diameters, non-significant effect of group or interaction was found but the ANOVA tests indicated a significant main effect of time from T0 to T1 within groups in all the diameters ($p< 0.01$ - 0.001) except for the wrist in Drop-out players. Even if the differences are not significant, it is worth noting that Club players had smaller perimeters but bigger diameters than the Drop-outs.

When analyzing skinfold thickness non-significant effect of time, group or interaction was observed. Nevertheless, Club players had less skinfold thickness than the Drop-out players. Also, even if the results are not statistically significant, Club players lost more fat during the season ($\mu^2= 0.02$). In fact, when analyzing fat percentage, a significant time effect was observed in Club players ($p< 0.01$) whilst no differences were found in Drop-outs. Results indicate that there was not a significant effect of group or interaction in the three indicators of body composition.

Regarding somatotype, no differences were observed during the season in the Drop-out players but a significant time effect was observed in Club players in both endomorphy and mesomorphy indicators ($p < 0.01$). Therefore, as endomorphy became smaller, players became significantly more mesomorph. Moreover, at the end of the season Club players were significantly less endomorph that Drop-outs ($p < 0.01$). Nevertheless, no interaction (time x group) effect was found in the somatotype indictors.

Physical performance

As shown in Table 4.4.3, ANOVA indicated a significant main effect of time for agility and dynamometry ($p < 0.001$) in the Drop-outs and for velocity and agility ($p < 0.001$) in the Club players, revealing an improvement of performance during the season. In the rest of the indicators, even if the results were not significant, a decrement in performance was observed in both groups, except for Yo-Yo IR1, were a small improvement was observed among Club players.

Also, the statistical analysis revealed a significant main effect of group for all the variables except for dynamometry ($p < 0.05$ - 0.001). Thus, compared to Drop-outs, Club players attained better overall results in physical performance indicators. Non-significant interaction (time x group) was observed. However, differences in magnitude revealed small effect sizes in velocity 15-m, agility and CMJ and large in Yo-Yo IR1 (μ^2= 0.01 - 0.15).

Maturation

Table 4.4.4 shows the estimated means of the maturation indicators. As expected, a logical time effect was observed in both groups ($p < 0.001$). Meantime, no group or interaction effects were observed among the rest of the variables. Thus, both groups presented similar results revealing high maturation homogeneity.

Table 4.4.2. Anthropometric characteristics of Club and Drop-out players of the Under-12 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Weight (kg)	39.50 ± 4.58	41.29 ± 4.33	1.79***	39.17 ± 5.13	40.87 ± 5.51	1.70***	-0.33^{ns}	-0.42^{ns}	0.997	0.000
Height (cm)	148.35 ± 5.57	151.39 ± 5.93	3.04***	148.60 ± 5.38	151.37 ± 5.74	2.77***	0.25^{ns}	-0.02^{ns}	0.636	0.005
Sitting Height (cm)	72.94 ± 2.99	73.50 ± 3.20	0.56**	72.88 ± 3.01	73.21 ± 3.24	0.33^{ns}	-0.06^{ns}	-0.29^{ns}	0.661	0.004
Leg lenght (cm)	76.24 ± 3.16	77.89 ± 3.63	1.65***	76.52 ± 3.59	78.15 ± 3.73	1.63***	0.28^{ns}	0.26^{ns}	0.517	0.008
BMI (cm/kg2)	17.92 ± 1.61	17.98 ± 1.29	0.06^{ns}	17.67 ± 1.34	17.77 ± 1.46	0.10^{ns}	-0.25^{ns}	-0.21^{ns}	0.747	0.002
Arm relaxed (cm)	22.61 ± 1.70	22.82 ± 1.51	0.21^{ns}	22.62 ± 1.74	22.52 ± 1.63	-0.10^{ns}	0.01^{ns}	-0.30^{ns}	0.267	0.025
Arm flexed (cm)	23.56 ± 1.74	23.81 ± 1.48	0.25^{ns}	23.76 ± 1.63	23.82 ± 1.75	0.06^{ns}	0.20^{ns}	0.01^{ns}	0.545	0.007
Thig (cm)	43.03 ± 3.04	42.94 ± 2.29	-0.09^{ns}	42.29 ± 3.03	42.63 ± 2.57	0.34^{ns}	-0.74^{ns}	-0.31^{ns}	0.329	0.019
Leg (cm)	30.83 ± 3.26	30.59 ± 1.84	-0.24^{ns}	30.22 ± 2.87	30.57 ± 1.94	0.35^{ns}	-0.61^{ns}	-0.02^{ns}	0.305	0.021
Elbow (cm)	5.75 ± 0.32	5.98 ± 0.23	0.23**	5.84 ± 0.41	6.04 ± 0.37	0.20**	0.09^{ns}	0.06^{ns}	0.788	0.001
Wrist (mm)	4.62 ± 0.25	4.77 ± 0.35	0.15^{ns}	4.70 ± 0.29	4.81 ± 0.30	0.11***	0.08^{ns}	0.04^{ns}	0.700	0.003
Knee (mm)	8.45 ± 0.62	9.07 ± 0.34	0.62***	8.53 ± 0.65	9.14 ± 0.42	0.61***	0.08^{ns}	0.07^{ns}	0.896	0.000
Ankle (mm)	5.98 ± 0.74	6.42 ± 0.36	0.44**	5.96 ± 0.60	6.51 ± 0.32	0.55***	-0.02^{ns}	0.09^{ns}	0.358	0.017
∑ Skinfolds (mm)	63.15 ± 23.58	62.87 ± 25.24	-0.28^{ns}	54.72 ± 19.95	51.18 ± 15.40	-3.54^{ns}	-8.43^{ns}	-11.69^{ns}	0.415	0.013
∑ Trunk Skinfolds (mm)	23.96 ± 11.81	23.15 ± 11.03	-0.81^{ns}	20.00 ± 10.32	18.41 ± 7.49	-1.59^{ns}	-3.96^{ns}	-4.74^{ns}	0.800	0.001
∑ Extremities Skinfolds (mm)	39.18 ± 12.73	39.72 ± 15.25	0.54^{ns}	34.72 ± 10.88	32.77 ± 9.10	-1.95^{ns}	-4.46^{ns}	-6.95^{ns}	0.229	0.029
Fat %	11.01 ± 2.15	10.88 ± 2.14	-0.13^{ns}	10.21 ± 1.92	9.83 ± 1.47	-0.38*	-0.80^{ns}	-1.05^{ns}	0.586	0.006
Bone %	18.54 ± 1.65	19.64 ± 1.66	1.10*	19.09 ± 1.31	20.07 ± 1.19	0.98*	0.55^{ns}	0.43^{ns}	0.880	0.000
Muscle %	46.34 ± 1.83	45.37 ± 1.71	-0.97*	46.59 ± 1.93	45.98 ± 1.27	-0.61*	0.25^{ns}	0.61^{ns}	0.592	0.006
Endomorphy	2.64 ± 1.06	2.53 ± 1.01	-0.11^{ns}	2.16 ± 0.85	1.97 ± 0.66	-0.19*	-0.48^{ns}	-0.56*	0.850	0.001
Mesomorphy	3.94 ± 1.16	4.10 ± 0.68	0.16^{ns}	3.97 ± 0.92	4.20 ± 0.76	0.23*	0.03^{ns}	0.10^{ns}	0.639	0.004
Ectomorphy	3.37 ± 0.97	3.52 ± 0.85	0.15^{ns}	3.51 ± 0.73	3.66 ± 0.86	0.15^{ns}	0.14^{ns}	0.14^{ns}	0.873	0.001

BMI: body mass index; ∑ skinfolds: sum of skinfolds; ∑ trunk skinfolds: sum of trunk skinfolds: ∑ extremities skinfolds: sum of extremities skinfolds.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$

Table 4.4.3. Physical performance characteristics of Club and Drop-out players of the Under-12 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Velocity (m/s)	5.84 ± 0.20	5.95 ± 0.20	0.11^{ns}	6.00 ± 0.23	6.15 ± 0.24	0.15^{***}	0.16^{*}	0.20^{*}	0.475	0.016
Agility (m/s)	2.05 ± 0.07	2.09 ± 0.07	0.04^{**}	2.12 ± 0.07	2.17 ± 0.05	0.05^{***}	0.07^{**}	0.08^{*}	0.557	0.010
Yo-Yo IR1 (m)	845.00 ± 343.05	822.22 ± 138.72	-22.78^{ns}	1102.40 ± 285.67	1227.36 ± 291.83	124.96^{ns}	257.40^{*}	405.14^{***}	0.122	0.155
CMJ (cm)	30.58 ± 3.01	30.36 ± 3.38	-0.22^{ns}	33.83 ± 5.06	33.80 ± 4.47	-0.03^{ns}	3.25^{**}	3.44^{*}	0.179	0.056
Dinamometry (kp)	23.90 ± 3.27	21.23 ± 4.12	-2.67^{**}	25.49 ± 4.07	24.16 ± 7.87	-1.33^{ns}	1.59^{ns}	2.93^{ns}	0.636	0.005

Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump; Dynamometry: hand dynamometry.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.4.4. Maturation characteristics of Club and Drop-out players of the Under-12 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
CA (years)	11.52 ± 0.25	12.11 ± 0.25	0.59^{***}	11.41 ± 0.29	12.00 ± 0.29	0.59^{***}	-0.11^{ns}	-0.11^{ns}	0.500	0.009
Maturity offset (years)	-3.12 ± 0.32	-2.82 ± 0.35	0.30^{***}	-3.18 ± 0.35	-2.92 ± 0.38	0.26^{***}	-0.06^{ns}	-0.10^{ns}	0.377	0.015
APHV (years)	14.64 ± 0.34	14.94 ± 0.38	0.30^{***}	14.59 ± 0.34	14.87 ± 0.42	0.28^{***}	-0.05^{ns}	-0.07^{ns}	0.840	0.001

CA: chronological age; APHV: age at peak height velocity.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{***}p< 0.001$.

4.4.3.1.2. UNDER-13 AGE GROUP

Anthropometry, body composition and somatotype

Table 4.4.5 shows the estimated means of anthropometric characteristics of the two groups at the beginning and at the end of the soccer season. Analysis revealed a main effect of time in both groups in height, weight, sitting height, leg length, BMI, circumferences and diameters ($p < 0.05$ - 0.001). Regarding group effect, at the start of the season groups were quite similar. However, at the end of the season, Club players were, on average, significantly higher, heavier and had larger leg length ($p < 0.05$).

In regard to skinfold thickness, Club players had larger amount of ∑ skinfold and ∑ trunk skinfold at the end of the season ($p < 0.01$). Nevertheless, when comparing with Drop-outs, significantly less skinfold thickness was observed at the beginning and at the end of the season in ∑ extremities´ skinfold. Moreover, even if the results are not significant, in general, Club players had less skinfold thickness in all the indicators than Drop-outs. Accordingly, significant gains in fat percentage were observed during the season in Club players ($p < 0.01$). Consequently, they become more endomorph from T0 to T1 ($p < 0.05$).

Statistical analysis indicates, on average, non-significant effect of time, group or interaction in body composition and somatotype dimensions in Drop-out players.

Physical performance

The physical performance results of the participants are presented in Table 4.4.6. Players who continued within the club improved significantly during the season their performance in the velocity and the agility indicators ($p< 0.001$), in the Yo-Yo IR1 ($p< 0.05$) and the CMJ ($p< 0.01$). Similarly, an improvement from T0 to T1 was observed in Drop-outs in the agility test, the Yo-Yo IR1 and the CMJ ($p< 0.01$). Group effect was only observed in the CMJ and the dynamometry, where Club players had better performances in both tests at T0 ($p< 0.01$). Non-significant interaction (time x group) was found in performance.

However, effect sizes indicate a small difference between magnitudes in agility and CMJ ($\mu^2= 0.01$) and a large difference in Yo-Yo IR1 ($\mu^2= 0.17$).

Maturation

Table 4.4.7 shows the means of the maturation indicators. Again, a logical effect of time was observed in both groups ($p< 0.001$). Nevertheless, no group or interaction effects were observed among the rest of the indicators, revealing similar maturity status.

Table 4.4.5. Anthropometric characteristics of Club and Drop-out players of the Under-13 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Weight (kg)	42.93 ± 5.67	43.32 ± 3.53	0.39^{***}	43.74 ± 6.81	47.36 ± 7.89	3.62^{***}	0.81^{ns}	4.04^{*}	0.289	0.032
Height (cm)	152.67 ± 7.26	153.97 ± 4.40	1.30^{***}	155.25 ± 6.72	159.31 ± 7.02	4.06^{***}	2.58^{ns}	5.34^{*}	0.988	0.000
Sitting Height (cm)	75.00 ± 3.86	75.67 ± 3.10	0.67^{*}	75.56 ± 3.75	77.44 ± 4.29	1.88^{***}	0.56^{ns}	1.77^{ns}	0.515	0.013
Leg lenght (cm)	77.96 ± 3.63	78.30 ± 2.33	0.34^{**}	80.77 ± 3.83	81.87 ± 3.70	1.10^{***}	2.81^{*}	3.57^{*}	0.117	0.071
BMI (cm/kg^2)	18.34 ± 1.00	18.25 ± 0.97	-0.09^{*}	18.03 ± 1.49	18.53 ± 1.64	0.50^{***}	-0.31^{ns}	0.28^{ns}	0.266	0.035
Arm relaxed (cm)	23.10 ± 1.51	22.81 ± 0.92	-0.29^{*}	22.86 ± 1.85	23.59 ± 1.96	0.73^{***}	-0.24^{ns}	0.78^{ns}	0.242	0.039
Arm flexed (cm)	24.50 ± 1.58	24.29 ± 1.16	-0.21^{**}	24.27 ± 1.87	25.14 ± 2.02	0.87^{***}	-0.23^{ns}	0.85^{ns}	0.279	0.033
Thig (cm)	43.35 ± 2.20	43.83 ± 2.00	0.48^{**}	43.06 ± 2.88	44.34 ± 3.01	1.28^{***}	-0.29^{ns}	0.51^{ns}	0.988	0.000
Leg (cm)	31.06 ± 1.66	31.11 ± 1.12	0.05^{*}	31.13 ± 2.48	32.15 ± 2.52	1.02^{***}	0.07^{ns}	1.04^{ns}	0.084	0.084
Elbow (mm)	6.14 ± 0.34	6.26 ± 0.32	0.12^{*}	6.11 ± 0.43	6.38 ± 0.37	0.27^{***}	-0.03^{ns}	0.12^{ns}	0.928	0.000
Wrist (mm)	4.97 ± 0.21	5.04 ± 0.18	0.07^{*}	4.88 ± 0.29	5.01 ± 0.34	0.13^{**}	-0.09^{ns}	-0.03^{ns}	0.690	0.005
Knee (mm)	9.33 ± 0.43	9.39 ± 0.36	0.06^{**}	9.29 ± 0.46	9.51 ± 0.45	0.22^{***}	-0.04^{ns}	0.12^{ns}	0.826	0.001
Ankle (mm)	6.81 ± 1.11	6.80 ± 0.34	-0.01^{**}	6.61 ± 0.38	6.86 ± 0.43	0.25^{***}	-0.20^{ns}	0.06^{ns}	0.251	0.037
∑Skinfolds (mm)	56.09 ± 7.95	55.66 ± 7.76	-0.43^{ns}	47.43 ± 15.26	51.44 ± 17.66	0.39^{**}	-8.66^{ns}	-4.22^{ns}	0.259	0.036
∑Trunk Skinfolds (mm)	19.56 ± 3.89	19.42 ± 3.78	-0.14^{ns}	18.01 ± 7.21	20.54 ± 10.30	2.53^{**}	-1.55^{ns}	1.12^{ns}	0.236	0.040
∑Extremities Skinfolds (mm)	36.52 ± 5.12	36.24 ± 4.76	-0.28^{ns}	29.42 ± 9.25	30.90 ± 8.93	1.48^{ns}	-7.10^{*}	-5.34^{*}	0.374	0.023
Fat %	10.17 ± 0.74	10.19 ± 0.88	0.02^{ns}	9.71 ± 1.43	10.13 ± 1.88	0.42^{**}	-0.46^{ns}	-0.06^{ns}	0.333	0.027
Bone %	20.07 ± 1.00	20.32 ± 1.23	0.25^{ns}	19.94 ± 0.96	19.82 ± 1.30	-0.12^{ns}	-0.13^{ns}	-0.50^{ns}	0.192	0.048
Muscle %	45.76 ± 1.04	45.73 ± 1.48	-0.03^{ns}	46.23 ± 1.07	45.50 ± 1.62	-0.73^{**}	0.47^{ns}	-0.23^{ns}	0.410	0.019
Endomorphy	2.17 ± 0.38	2.27 ± 0.53	0.10^{ns}	1.85 ± 0.64	1.98 ± 1.62	0.13^{*}	-0.32^{ns}	-0.29^{ns}	0.726	0.004
Mesomorphy	4.37 ± 0.50	4.29 ± 0.40	-0.08^{ns}	4.02 ± 0.79	4.14 ± 0.70	0.12^{ns}	-0.35^{ns}	-0.15^{ns}	0.303	0.030
Ectomorphy	3.38 ± 0.64	3.53 ± 0.64	0.15^{ns}	3.77 ± 0.70	3.76 ± 0.71	-0.01^{ns}	0.39^{ns}	0.23^{ns}	0.268	0.035

BMI: body mass index; ∑ skinfolds: sum of skinfolds; ∑ trunk skinfolds: sum of trunk skinfolds: ∑ extremities skinfolds: sum of extremities skinfolds.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.4.6. Physical performance characteristics of Club and Drop-out players of the Under-13 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Velocity (m/s)	6.17 ± 0.35	6.79 ± 0.49	0.62^{ns}	6.23 ± 0.23	6.69 ± 0.59	0.46^{***}	0.06^{ns}	-0.10^{ns}	0.829	0.002
Agility (m/s)	2.13 ± 0.04	2.22 ± 0.04	0.09^{**}	2.18 ± 0.07	2.23 ± 0.08	0.05^{***}	0.05^{ns}	0.01^{ns}	0.504	0.015
Yo-Yo IR1 (m)	1040.00 ± 185.47	1468.00 ± 227.09	428^{**}	1213.33 ± 249.23	1440.00 ± 275.68	226.67^{*}	173.33^{ns}	-28.0^{ns}	0.060	0.174
CMJ (cm)	31.28 ± 2.49	33.18 ± 3.39	1.90^{**}	35.33 ± 4.29	36.22 ± 4.65	0.89^{**}	4.05^{**}	3.04^{ns}	0.580	0.010
Dinamometry (kp)	23.45 ± 3.41	23.80 ± 2.97	0.35^{ns}	28.88 ± 4.22	29.29 ± 5.67	0.41^{ns}	5.43^{**}	5.49^{*}	0.645	0.006

Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump; Dynamometry: hand dynamometry.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; vs.: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.4.7. Maturation characteristics of Club and Drop-out players of the Under-13 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
CA (years)	12.16 ± 0.28	12.88 ± 0.28	0.72^{***}	12.38 ± 0.29	13.10 ± 0.29	0.72^{***}	0.22^{*}	0.22^{*}	0.004	0.187
Maturity offset (years)	-2.64 ± 0.49	-2.26 ± 0.43	0.38^{***}	-2.51 ± 0.42	-2.00 ± 0.51	0.51^{***}	0.13^{ns}	0.26^{ns}	0.524	0.012
APHV (years)	14.80 ± 0.39	15.16 ± 0.28	0.36^{***}	14.85 ± 0.48	15.04 ± 0.53	0.19^{***}	0.05^{ns}	-0.12^{ns}	0.823	0.002

CA: chronological age; APHV: age at peak height velocity.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; vs.: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{***}p< 0.001$.

4.4.3.1.3. UNDER-14 AGE GROUP

Anthropometry, body composition and somatotype

Table 4.4.8 summarizes the means for the anthropometric characteristics of the two groups during the season. ANOVA indicated a significant main effect of time for height, weight, sitting height, BMI and circumferences from T0 to T1 within groups ($p< 0.05$ - 0.001). Yet, in diameters, effect of time was only significant in the Drop-outs ($p< 0.01$). Non-significant effect of group or interaction was observed in the mentioned indicators. However, in general, Club players had greater body size than their peers that left the club.

In relation to somatotype, both groups become less mesomorph during the season ($p< 0.001$). Although no other significant differences were identified in time, group or interaction, players who achieved to progress in the club had less fat and were less endomorph than players who left it and, interestingly, as mesomorphy decreased ($p< 0.05$, $\mu^2= 0.14$), they become more ectomorph.

Physical performance

As shown in Table 4.4.9, both groups attained better results in all the physical performance variables at T1 ($p< 0.05$ - 0.001). When accounting for group effect, at the start of the season Club players had significantly better results in the Yo-Yo IR1 and the dynamometry test than Drop-outs ($p< 0.05$). Nonetheless, these differences disappeared at the end of the season. It is worth noting that although non-significant interaction (time x group) was observed in physical performance indicators, effect sizes indicate medium differences in agility and CMJ ($\mu^2 = 0.08$ and $\mu^2 = 0.12$, respectively).

Maturation

Table 4.4.10 shows the estimated means of the maturation indicators. Again, a logical effect of time was observed in both groups in CA and maturity offset ($p< 0.001$). Nonetheless, no differences were observed during the season in APHV. Also, no group or interaction effects were observed among the rest of the indicators

Table 4.4.8. Anthropometric characteristics of Club and Drop-out players of the Under-14 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Weight (kg)	48.55 ± 6.04	52.98 ± 5.75	4.43***	52.50 ± 8.80	56.89 ± 8.45	4.39***	3.95^{ns}	3.91^{ns}	0.306	0.037
Height (cm)	161.08 ± 7.11	165.55 ± 6.72	4.47***	164.34 ± 7.99	169.19 ± 6.82	4.85***	3.26^{ns}	3.64^{ns}	0.960	0.000
Sitting Height (cm)	77.45 ± 3.38	80.96 ± 3.68	3.51***	79.21 ± 5.51	83.42 ± 4.49	4.21***	1.76^{ns}	2.46^{ns}	0.995	0.000
Leg lenght (cm)	83.63 ± 4.66	84.58 ± 4.05	0.95*	85.12 ± 4.26	85.77 ± 3.62	0.65^{ns}	1.49^{ns}	1.19^{ns}	0.970	0.000
BMI (cm/kg^2)	18.64 ± 1.09	19.28 ± 1.16	0.64**	19.29 ± 1.73	19.77 ± 1.82	0.48*	0.65^{ns}	0.49^{ns}	0.119	0.084
Arm relaxed (cm)	23.86 ± 1.34	24.71 ± 1.65	0.85**	24.64 ± 1.88	25.42 ± 2.04	0.78*	0.78^{ns}	0.71^{ns}	0.247	0.048
Arm flexed (cm)	25.25 ± 1.28	26.28 ± 1.53	1.03**	26.15 ± 2.04	27.03 ± 2.04	0.88*	0.90^{ns}	0.75^{ns}	0.314	0.036
Thig (cm)	44.75 ± 1.96	46.61 ± 2.32	1.86***	45.71 ± 3.71	47.81 ± 3.44	2.10***	0.96^{ns}	1.20^{ns}	0.629	0.008
Leg (cm)	32.25 ± 2.07	32.90 ± 1.88	0.65*	33.67 ± 2.89	33.68 ± 2.51	0.01^{ns}	1.42^{ns}	0.78^{ns}	0.337	0.033
Elbow (mm)	6.45 ± 0.33	6.60 ± 0.40	0.15*	6.58 ± 0.39	6.57 ± 0.51	-0.01^{ns}	0.13^{ns}	-0.03^{ns}	0.187	0.061
Wrist (mm)	5.08 ± 0.31	5.24 ± 0.24	0.16*	5.23 ± 0.34	5.33 ± 0.28	0.10^{ns}	0.15^{ns}	0.09^{ns}	0.844	0.001
Knee (mm)	9.50 ± 0.35	9.55 ± 0.26	0.05^{ns}	9.72 ± 0.42	9.69 ± 0.41	-0.03^{ns}	0.22^{ns}	0.14^{ns}	0.974	0.000
Ankle (mm)	6.72 ± 0.31	7.00 ± 0.38	0.28**	7.03 ± 0.34	7.01 ± 0.33	-0.02^{ns}	0.31*	0.01^{ns}	0.093	0.097
∑Skinfolds (mm)	52.27 ± 18.60	51.18 ± 16.73	-1.09^{ns}	49.47 ± 10.97	47.88 ± 12.35	-1.59^{ns}	-2.80^{ns}	-3.30^{ns}	0.970	0.000
∑Trunk Skinfolds (mm)	21.47 ± 10.69	20.90 ± 7.82	-0.57^{ns}	20.12 ± 5.53	21.29 ± 6.40	1.17^{ns}	-1.35^{ns}	0.39^{ns}	0.359	0.030
∑Extremities Skinfolds (mm)	30.80 ± 8.88	30.27 ± 9.89	-0.53^{ns}	29.35 ± 6.96	26.59 ± 6.83	-2.76^{ns}	-1.45^{ns}	-3.68^{ns}	0.457	0.020
Fat %	10.35 ± 0.31	10.22 ± 1.65	-0.13^{ns}	10.04 ± 1.06	10.19 ± 1.24	0.15^{ns}	-0.31^{ns}	-0.03^{ns}	0.395	0.026
Bone %	19.73 ± 1.36	19.26 ± 0.33	-0.47*	19.57 ± 1.24	18.70 ± 2.72	-0.87^{ns}	-0.16^{ns}	-0.56^{ns}	0.494	0.017
Muscle %	45.81 ± 1.76	46.40 ± 1.30	0.59^{ns}	46.27 ± 1.14	47.02 ± 2.35	0.75^{ns}	0.46^{ns}	0.62^{ns}	0.189	0.041
Endomorphy	2.06 ± 0.81	2.08 ± 0.98	0.02^{ns}	1.93 ± 0.46	1.90 ± 0.49	-0.03^{ns}	-0.13^{ns}	-0.18^{ns}	0.367	0.029
Mesomorphy	4.03 ± 0.70	3.86 ± 0.76	-0.17*	4.23 ± 0.93	3.73 ± 0.87	-0.50***	0.20^{ns}	-0.13^{ns}	0.037	0.147
Ectomorphy	3.79 ± 0.63	3.72 ± 0.71	-0.07^{ns}	3.66 ± 0.77	3.72 ± 0.86	0.06^{ns}	-0.13^{ns}	0.00^{ns}	0.120	0.084

BMI: body mass index; ∑ skinfolds: sum of skinfolds; ∑ trunk skinfolds: sum of trunk skinfolds: ∑ extremities skinfolds: sum of extremities skinfolds.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.4.9. Physical performance characteristics of Club and Drop-out players of the Under-14 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Velocity (m/s)	6.37 ± 0.28	7.17 ± 0.44	0.80***	6.54 ± 0.34	7.11 ± 0.57	0.57***	0.17ns	-0.06ns	0.206	0.053
Agility (m/s)	2.18 ± 0.07	2.26 ± 0.06	0.08***	2.21 ± 0.09	2.25 ± 0.07	0.04*	0.03ns	-0.01ns	0.091	0.089
Yo-Yo IR1 (m)	1224.00 ± 219.25	1937.77 ± 297.39	713.77***	1428.33 ± 322.05	2090.52 ± 247.23	662.19***	204.33*	152.75ns	0.289	0.043
CMJ (cm)	37.51 ± 4.06	40.81 ± 3.68	3.30**	38.06 ± 4.52	40.96 ± 4.61	2.90***	0.55ns	0.15ns	0.054	0.122
Dinamometry (kp)	29.18 ± 2.44	33.16 ± 3.24	3.98**	32.55 ± 7.09	38.80 ± 6.16	6.25***	3.37*	5.64ns	0.133	0.081

Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump; Dynamometry: hand dynamometry.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; vs.: versus; n.s: non-significant.
*p< 0.05; **p< 0.01; ***p< 0.001.

Table 4.4.10. Maturation characteristics of Club and Drop-out players of the Under-14 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Drop-out			Club			§ Club *vs.* Drop-out		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
CA (years)	13.33 ± 0.30	14.07 ± 0.30	0.74***	13.35 ± 0.25	14.09 ± 0.25	0.74***	0.02ns	0.02ns	0.012	0.166
Maturity offset (years)	-1.88 ± 0.45	-1.13 ± 0.52	0.75***	-1.62 ± 0.80	-0.82 ± 0.58	0.80***	0.26ns	0.31ns	0.978	0.000
APHV (years)	15.21 ± 0.38	15.20 ± 0.42	-0.01ns	14.98 ± 0.75	14.91 ± 0.57	-0.07ns	-0.23ns	-0.29ns	0.764	0.003

CA: chronological age; APHV: age at peak height velocity.
§: Differences between Club players versus Drop-outs; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
***p< 0.001.

4.4.3.2. Club players *vs.* Enter players

4.4.3.2.1. UNDER-12 AGE GROUP

Anthropometry, body composition and somatotype

Table 4.4.11 summarizes the means of the anthropometric characteristics of the players who already were in the club (Club players) in comparison to the players who entered the club (Enter group) at the beginning and at the end of the soccer season. Significant gains in weight, height and BMI were observed in both groups from T0 to T1 ($p < 0.01$ - 0.001). Nevertheless, whereas in leg length and sitting height non-significant effect of time was found in Enter players, substantial increments were observed in Club players ($p < 0.001$). Also, it is interesting to note that, although differences between groups were not significant at T0 and T1, players who entered the club appeared to be higher, heavier and have larger body size than players who already pertained to the club.

In regard to circumferences and diameters, effect of time in circumferences appeared in the Enter players ($p < 0.05$ - 0.01). In contrast, in the Club players, significant and higher differences were observed in both circumferences and diameters ($p < 0.001$) revealing growth in size during the season. Non-significant effect of groups or interaction was found. However, it is interesting to underline that Enter players had bigger circumferences and diameters than Club players.

During the season, significant gains in ∑ skinfold ($p < 0.01$), ∑ trunk skinfold ($p < 0.01$) and ∑ extremities skinfold ($p < 0.001$) were observed in the Enter players. Consequently, significant differences from T10 to T1 were also found in fat percentage and endomorphy ($p < 0.01$). Similarly, in Club players, the effect of time was also noticeable in ∑ extremities skinfold ($p < 0.01$) and in fat percentage ($p < 0.01$). Non-significant effect of group or interaction was found.

Physical performance

Table 4.4.12 shows the results of physical performance tests of the players of both groups during the season. Whereas in the players who entered the club significant differences from T0 to T1 were only observed in agility ($p < 0.01$), Club players revealed an improvement of performance during the season in all the physical performance indicators ($p < 0.001$) with the exception of dynamometry. No effects of group were observed in the performance indicators. Nonetheless, a significant interaction (time x group) was observed in the Yo-Yo IR1 ($p < 0.05$; $\mu^2 = 0.29$). Moreover, it is interesting to note that while at T0 Enter players had better performance results in the test (1346.67 ± 83.27 meters), at T1 Club players achieved to run 217 meters more than their peers.

Maturation

As it is shown in Table 4.4.13, effects of time in CA were obvious in both groups ($p < 0.001$). Besides, whereas time effect was observed in both groups in maturity offset ($p < 0.001$), differences in APHV during the season were only observed in Club players ($p < 0.001$). No group or interaction effects were observed among the indicators.

Table 4.4.11. Anthropometric characteristics of Club and Enter players of the Under-12 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Enter			Club			§ Club *vs.* Enter		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Weight (kg)	44.82 ± 9.28	49.55 ± 11.05	4.73^{**}	43.27 ± 5.96	45.75 ± 6.36	2.48^{***}	-1.55^{ns}	-3.80^{ns}	0.124	0.066
Height (cm)	156.48 ± 9.48	160.53 ± 9.61	4.05^{**}	154.12 ± 6.47	157.48 ± 6.27	3.36^{***}	-2.36^{ns}	-3.05^{ns}	0.898	0.000
Sitting Height (cm)	76.13 ± 4.94	78.07 ± 5.43	1.94^{ns}	75.25 ± 3.57	76.79 ± 3.83	1.54^{***}	-0.88^{ns}	-1.28^{ns}	0.851	0.001
Leg lenght (cm)	81.72 ± 5.21	82.47 ± 4.83	0.75^{ns}	79.58 ± 3.69	80.68 ± 3.52	1.10^{***}	-2.14^{ns}	-1.79^{ns}	0.375	0.023
BMI (cm/kg^2)	18.12 ± 1.70	19.01 ± 2.05	0.89^{**}	18.13 ± 1.32	18.36 ± 1.39	0.23^{**}	0.01^{ns}	-0.65^{ns}	0.075	0.088
Arm relaxed (cm)	22.93 ± 2.22	23.60 ± 2.42	0.67^{*}	22.94 ± 1.69	23.36 ± 1.68	0.42^{***}	0.01^{ns}	-0.24^{ns}	0.891	0.001
Arm flexed (cm)	24.32 ± 2.51	25.32 ± 2.90	1.00^{**}	24.35 ± 1.67	24.86 ± 1.67	0.51^{***}	0.03^{ns}	-0.46^{ns}	0.584	0.009
Thig (cm)	43.78 ± 2.68	45.48 ± 3.65	1.70^{ns}	43.04 ± 2.70	44.02 ± 2.62	0.98^{***}	-0.74^{ns}	-1.46^{ns}	0.711	0.004
Leg (cm)	31.47 ± 3.09	32.97 ± 3.20	1.50^{***}	31.05 ± 2.12	31.69 ± 2.08	0.64^{***}	-0.42^{ns}	-1.28^{ns}	0.061	0.097
Elbow (mm)	6.33 ± 0.47	6.45 ± 0.39	0.12^{ns}	6.08 ± 0.40	6.33 ± 0.37	0.25^{***}	-0.25^{ns}	-0.12^{ns}	0.114	0.070
Wrist (mm)	5.00 ± 0.36	5.10 ± 0.42	0.10^{ns}	4.90 ± 0.26	5.01 ± 0.29	0.11^{***}	-0.10^{ns}	-0.09^{ns}	0.709	0.004
Knee (mm)	9.42 ± 0.55	9.63 ± 0.58	0.21^{**}	9.29 ± 0.44	9.46 ± 0.41	0.17^{***}	-0.13^{ns}	-0.17^{ns}	0.822	0.001
Ankle (mm)	6.73 ± 0.48	7.00 ± 0.59	0.27^{ns}	6.66 ± 0.72	6.82 ± 0.37	0.16^{***}	-0.07^{ns}	-0.18^{ns}	0.823	0.001
∑Skinfolds (mm)	43.53 ± 8.30	51.05 ± 10.45	7.52^{**}	51.18 ± 14.53	52.79 ± 16.63	1.61^{ns}	7.65^{ns}	1.74^{ns}	0.177	0.051
∑Trunk Skinfolds (mm)	16.92 ± 3.19	20.03 ± 4.76	3.11^{**}	18.75 ± 6.80	20.29 ± 9.68	1.54^{**}	1.83^{ns}	0.26^{ns}	0.626	0.007
∑Extremities Skinfolds (mm)	26.62 ± 6.07	31.02 ± 6.95	4.40^{***}	32.43 ± 8.99	32.50 ± 8.66	0.07^{ns}	5.81^{ns}	1.48^{ns}	0.053	0.103
Fat %	9.44 ± 0.65	10.07 ± 0.91	0.63^{**}	9.93 ± 1.35	10.17 ± 1.79	0.24^{*}	0.49^{ns}	0.10^{ns}	0.418	0.019
Bone %	20.27 ± 1.05	19.67 ± 1.66	-0.60^{ns}	19.93 ± 0.95	20.00 ± 1.24	0.07^{ns}	-0.34^{ns}	0.33^{ns}	0.040	0.115
Muscle %	46.18 ± 1.35	44.04 ± 2.41	-2.14^{ns}	46.08 ± 1.04	45.84 ± 1.23	-0.24^{*}	-0.10^{ns}	1.80^{ns}	0.001	0.288
Endomorphy	1.68 ± 0.26	1.98 ± 0.38	0.30^{**}	2.00 ± 0.63	2.08 ± 0.74	0.08^{ns}	0.32^{ns}	0.10^{ns}	0.215	0.044
Mesomorphy	4.21 ± 0.78	4.24 ± 0.81	0.03^{ns}	4.12 ± 0.73	4.18 ± 0.62	0.06^{ns}	-0.09^{ns}	-0.06^{ns}	0.563	0.010
Ectomorphy	3.81 ± 0.74	3.58 ± 0.78	-0.23^{ns}	3.63 ± 0.70	3.73 ± 0.69	0.10^{ns}	-0.18^{ns}	0.15^{ns}	0.085	0.082

BMI: body mass index; ∑ skinfolds: sum of skinfolds; ∑ trunk skinfolds: sum of trunk skinfolds: ∑ extremities skinfolds: sum of extremities skinfolds.
§: Differences between Club players versus Enter players; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.4.12. Physical performance characteristics of Club and Enter players of the Under-12 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Enter			Club			§ Club *vs.* Enter		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Velocity (m/s)	6.34 ± 0.27	6.64 ± 0.61	0.30^{ns}	6.20 ± 0.27	6.74 ± 0.56	0.54^{***}	-0.14^{ns}	0.10^{ns}	0.324	0.031
Agility (m/s)	2.18 ± 0.07	2.24 ± 0.06	0.06^{**}	2.16 ± 0.08	2.23 ± 0.07	0.07^{***}	-0.02^{ns}	-0.01^{ns}	0.685	0.005
Yo-Yo IR1 (m)	1346.67 ± 83.27	1273.33 ± 108.57	-73.34^{ns}	1131.67 ± 244.45	1491.20 ± 266.21	359.53^{***}	-215^{ns}	217.87^{ns}	0.011	0.297
CMJ (cm)	35.96 ± 5.40	36.03 ± 4.58	0.07^{ns}	33.88 ± 4.07	35.31 ± 4.57	1.43^{***}	-2.08^{ns}	-0.72^{ns}	0.189	0.057
Dinamometry (kp)	28.33 ± 4.13	28.17 ± 5.23	-0.16^{ns}	27.13 ± 4.82	27.74 ± 5.77	0.61^{ns}	-1.20^{ns}	-0.43^{ns}	0.482	0.015

Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump; Dynamometry: hand dynamometry.
§: Differences between Club players versus Enter players; #: Differences between T0 and T1; vs.: versus; n.s: non-significant.
$^{**}p < 0.01$; $^{***}p < 0.001$.

Table 4.4.13. Maturation characteristics of Club and Enter players of the Under-12 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Enter			Club			§ Club *vs.* Enter		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
CA (years)	12.33 ± 0.16	12.99 ± 0.15	0.66^{***}	12.31 ± 0.33	12.97 ± 0.32	0.66^{***}	-0.02^{ns}	-0.02^{ns}	0.325	0.024
Maturity offset (years)	-2.45 ± 0.58	-1.95 ± 0.65	0.50^{***}	-2.58 ± 0.43	-2.09 ± 0.48	0.49^{***}	-0.13^{ns}	-0.14^{ns}	0.949	0.000
APHV (years)	14.78 ± 0.54	14.94 ± 0.61	0.16^{ns}	14.85 ± 0.44	15.10 ± 0.46	0.25^{***}	0.07^{ns}	0.16^{ns}	0.723	0.004

CA: chronological age; APHV: age at peak height velocity.
§: Differences between Club players versus Enter players; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{***}p < 0.001$.

4.4.3.2.2. UNDER-13 AGE GROUP

Anthropometry, body composition and somatotype

Table 4.4.14 summarizes the estimated means for the anthropometric characteristics of the two groups during the season. Results revealed a main effect of time in weight, height, sitting height, BMI ($p < 0.001$) and leg length ($p < 0.01$) in Club players. Conversely, non-significant time effect was observed in the Enter players. Besides, significant differences between groups were observed at T0 and T1 revealing that Club players were significantly lighter ($p < 0.05$) and shorter ($p < 0.05$). Nevertheless, non-significant interaction (time x group) was found.

ANOVA indicated significant differences during the season in Club players in three of the four circumferences: arm relaxed ($p < 0.001$), arm flexed ($p < 0.001$) and thigh ($p < 0.001$). Also, differences between T0 and T1 were observed in this group in the diameters of the wrist ($p < 0.05$) and ankle ($p < 0.01$). Conversely, time effect was not substantial in circumferences and diameters in Enter players. Nevertheless, when comparing the groups, Club players appeared to have significantly smaller thigh circumference than Enter players in both the beginning and the end of the season ($p < 0.05$). Non-significant interaction (time x group) was observed.

When analyzing somatotype, significant differences from T0 to T1 were only considerable in mesomorphy ($p < 0.001$) in Club players revealing a decrease of mesomorphy in the group. Also, it was observed that at T0 Club players had significantly less ∑ trunk skinfolds ($p < 0.05$) and, consequently, less fat percentage ($p < 0.05$). Interestingly, these differences disappear at T1. No other effects of time, group or interaction were found.

Physical performance

As shown in Table 4.4.15, significant performance improvements were observed during the season in velocity 15-m, Yo-Yo IR1, CMJ, dynamometry ($p < 0.001$) and agility ($p < 0.01$) in Club players and, similarly, in agility ($p < 0.05$) and Yo-Yo IR1 ($p < 0.01$) in the Enter players. Regarding group effect, significant differences between the two groups were found at T0 in all the physical performance variables ($p < 0.05$ - 0.01) with exception of Yo-Yo IR1. Thus, Enter players appeared to have better overall performance at the beginning of the season than Club players. However, at the end of the season most of these differences disappeared, except in dynamometry where Enter players continued to perform better than their peers. As well, a significant interaction (time x group) was observed in agility ($p < 0.05$; $\mu^2 = 0.18$). Thereby, it seems that players who entered the club improve significantly more during the season and have better results at the end of the season than Club players.

Maturation

Maturation characteristic of Club players and enter players of the Under-13 category are shown Table 4.4.16. A logical effect of time was observed in CA in both groups ($p < 0.001$). Also, significant differences from T0 to T1 were found in maturity offset in Club players ($p < 0.001$). However, non-significant effects of time were observed in maturity offset among the Enter players. Differently from what happens in other categories, group differences were detected in this category. Thus, Enter players appeared to be significantly older than club players. Also, Enter players appeared to be significantly closer from their maturity offset than Club players. This difference was larger in T1 ($p < 0.01$) than in T0 ($p < 0.05$). No interaction effect was detected between the indicators

Table 4.4.14. Anthropometric characteristics of Club and Enter players of the Under-13 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Enter			Club			§ Club *vs.* Enter		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Weight (kg)	63.40 ± 4.10	61.61 ± 6.11	-1.79^{ns}	50.03 ± 7.41	53.98 ± 7.50	3.95^{***}	-13.37^{*}	-7.63^{*}	0.408	0.025
Height (cm)	173.25 ± 5.70	175.75 ± 4.60	2.50^{ns}	162.13 ± 7.08	166.57 ± 6.59	4.44^{***}	-11.12^{*}	-9.18^{**}	0.154	0.071
Sitting Height (cm)	85.35 ± 1.63	86.51 ± 2.89	1.16^{ns}	78.02 ± 4.56	81.55 ± 4.10	3.53^{***}	-7.33^{*}	-4.96^{**}	0.600	0.010
Leg lenght (cm)	86.74 ± 4.56	90.40 ± 6.22	3.66^{ns}	84.11 ± 4.09	85.01 ± 3.50	0.90^{*}	-2.63^{ns}	-5.39^{ns}	0.164	0.068
BMI (cm/kg^2)	20.58 ± 2.40	20.52 ± 1.67	-0.06^{ns}	18.93 ± 1.44	1 9.37 ± 1.57	0.44^{***}	-1.65^{ns}	-1.15^{ns}	0.648	0.008
Arm relaxed (cm)	26.00 ± 1.13	26.48 ± 1.49	0.48^{ns}	24.21 ± 1.69	24.84 ± 1.91	0.63^{***}	-1.79^{ns}	-1.64^{ns}	0.773	0.003
Arm flexed (cm)	27.15 ± 1.06	27.94 ± 1.75	0.79^{ns}	25.70 ± 1.83	26.47 ± 1.85	0.77^{***}	-1.45^{ns}	-1.47^{ns}	0.414	0.024
Thig (cm)	49.80 ± 4.53	50.35 ± 2.90	0.55^{ns}	45.01 ± 2.86	46.62 ± 2.74	1.61^{***}	-4.79^{*}	-3.73^{*}	0.204	0.057
Leg (cm)	34.30 ± 3.54	34.24 ± 2.29	-0.06^{ns}	33.02 ± 2.64	33.21 ± 2.33	0.19^{ns}	-1.28^{ns}	-1.03^{ns}	0.848	0.001
Elbow (mm)	6.85 ± 0.35	6.76 ± 0.37	-0.09^{ns}	6.51 ± 0.37	6.54 ± 0.50	0.03^{ns}	-0.34^{ns}	-0.22^{ns}	0.522	0.015
Wrist (mm)	5.50 ± 0.14	5.35 ± 0.21	-0.15^{ns}	5.15 ± 0.33	6.76 ± 0.37	1.61^{*}	-0.35^{ns}	1.41^{ns}	0.293	0.039
Knee (mm)	10.00 ± 0.14	9.69 ± 0.38	-0.31^{ns}	9.61 ± 0.40	9.63 ± 0.38	0.02^{ns}	-0.39^{ns}	-0.06^{ns}	0.779	0.003
Ankle (mm)	7.00 ± 0.14	6.89 ± 0.34	-0.11^{ns}	6.91 ± 0.37	7.04 ± 0.35	0.13^{**}	-0.09^{ns}	0.15^{ns}	0.355	0.031
∑Skinfolds (mm)	63.35 ± 6.29	51.90 ± 13.70	-11.45^{ns}	49.69 ± 14.31	48.14 ± 13.93	-1.55^{ns}	-13.66^{*}	-3.76^{ns}	0.347	0.032
∑Trunk Skinfolds (mm)	31.70 ± 3.82	25.06 ± 7.19	-6.64^{ns}	19.88 ± 7.49	20.10 ± 6.39	0.22^{ns}	-11.82^{*}	-4.96^{ns}	0.769	0.003
∑Extremities Skinfolds (mm)	31.65 ± 2.47	26.84 ± 6.79	-4.81^{ns}	29.81 ± 7.93	28.05 ± 8.40	-1.76^{ns}	-1.84^{ns}	1.21^{ns}	0.253	0.046
Fat %	12.09 ± 0.57	10.86 ± 1.43	-1.23^{ns}	10.03 ± 1.49	10.02 ± 1.32	-0.01^{ns}	-2.06^{*}	-0.84^{ns}	0.488	0.017
Bone %	18.71 ± 2.06	16.87 ± 3.67	-1.84^{ns}	19.71 ± 1.23	19.44 ± 1.53	-0.27^{ns}	1.00^{ns}	2.57^{ns}	0.675	0.006
Muscle %	45.10 ± 1.48	48.17 ± 3.47	3.07^{ns}	46.16 ± 1.41	46.45 ± 1.37	0.29^{ns}	1.06^{ns}	-1.72^{ns}	0.966	0.000
Endomorphy	2.56 ± 0.47	2.15 ± 0.59	-0.41^{ns}	1.95 ± 0.61	1.92 ± 0.71	-0.03^{ns}	-0.61^{ns}	-0.23^{ns}	0.459	0.020
Mesomorphy	3.43 ± 1.12	3.63 ± 0.76	0.20^{ns}	4.21 ± 0.82	3.82 ± 0.86	-0.39^{***}	0.78^{ns}	0.19^{ns}	0.223	0.052
Ectomorphy	3.71 ± 1.54	3.57 ± 0.96	-0.14^{ns}	3.72 ± 0.68	3.77 ± 0.78	0.05^{ns}	0.01^{ns}	0.20^{ns}	0.940	0.000

BMI: body mass index; ∑ skinfolds: sum of skinfolds; ∑ trunk skinfolds: sum of trunk skinfolds: ∑ extremities skinfolds: sum of extremities skinfolds.
§: Differences between Club players versus Enter players; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.4.15. Physical performance characteristics of Club and Enter players of the Under-13 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Enter			Club			§ Club *vs.* Enter		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig.	μ^2
Velocity (m/s)	6.83 ± 0.19	7.32 ± 0.58	0.49^{ns}	6.40 ± 0.30	7.08 ± 0.51	0.68^{***}	-0.43^{**}	-0.24^{ns}	0.326	0.032
Agility (m/s)	2.15 ± 0.06	2.26 ± 0.07	0.11^{*}	2.22 ± 0.09	2.25 ± 0.07	0.03^{**}	0.07^{*}	-0.01^{ns}	0.012	0.187
Yo-Yo IR1 (m)	1195.00 ± 167.59	2020.00 ± 161.49	825^{**}	1421.54 ± 322.64	2047.27 ± 294.10	625.73^{***}	226.54^{ns}	27.27^{ns}	0.077	0.116
CMJ (cm)	41.06 ± 3.33	42.86 ± 4.78	1.80^{ns}	37.00 ± 4.21	40.37 ± 4.04	3.37^{***}	-4.06^{*}	-2.49^{ns}	0.036	0.142
Dinamometry (kp)	38.00 ± 5.16	42.06 ± 5.21	4.06^{ns}	30.20 ± 5.42	35.57 ± 5.45	5.37^{***}	-7.80^{*}	-6.49^{**}	0.511	0.016

Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump; Dynamometry: hand dynamometry.
§: Differences between Club players versus Enter players; #: Differences between T0 and T1; vs.: versus; n.s: non-significant.
$^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.4.16. Maturation characteristics of players of Club and Enter players of the Under-13 age group determined at the beginning (T0) and end (T1) of the season (mean ± SD).

	Enter			Club			§ Club *vs.* Enter		Interaction	
	T0	T1	#	T0	T1	#	T0	T1	Sig	μ^2
CA (years)	13.51 ± 0.12	14.25 ± 0.12	0.74^{***}	13.30 ± 0.28	14.04 ± 0.28	0.74^{***}	-0.21^{**}	-0.21^{**}	0.065	0.094
Maturity offset (years)	-0.96 ± 1.14	-0.36 ± 0.38	0.60^{ns}	-1.83 ± 0.56	-1.08 ± 0.52	0.75^{***}	-0.87^{*}	-0.72^{**}	0.786	0.002
APHV (years)	14.63 ± 1.05	14.61 ± 0.35	-0.02^{ns}	15.13 ± 0.57	15.12 ± 0.54	-0.01^{ns}	0.50^{ns}	0.51^{*}	0.205	0.053

CA: chronological age; APHV: age at peak height velocity.
§: Differences between Club players versus Enter players; #: Differences between T0 and T1; *vs.*: versus; n.s: non-significant.
$^{*}p< 0.05$;$^{**}p< 0.01$;$^{***}p< 0.001$.

4.4.3.3. Relative Age Effect (RAE)

Analysis of date of birth of all the players revealed that 66 % had been born in the first semester and 33 % in the second. Results are similar when analyzing birth dates among the different groups (Table 4.4.16 and Figure 4.4.2). The percentages of players born in the first semester of the selection year were 69.23 %, 63.63 %, 68.88 % for Enter players, Club players and Drop-out players, respectively. In contrast, the percentage of players born in the second semester was significantly lower. Therefore, a significant predominance of players born in the first semester was observed in all the groups. However, the tendency was more obvious in the Enter players.

Table 4.4.16. Number of players and semester birth date distribution of all the soccer players by selected groups.

	Number of players	Semester of birth (%)		χ^2	Sig.
		First	Second		
Club	90	63.63	36.36	7.430	0.006
Drop-out	44	68.88	31.1	14.276	0.000
Enter	21	69.23	30.76	14.801	0.000

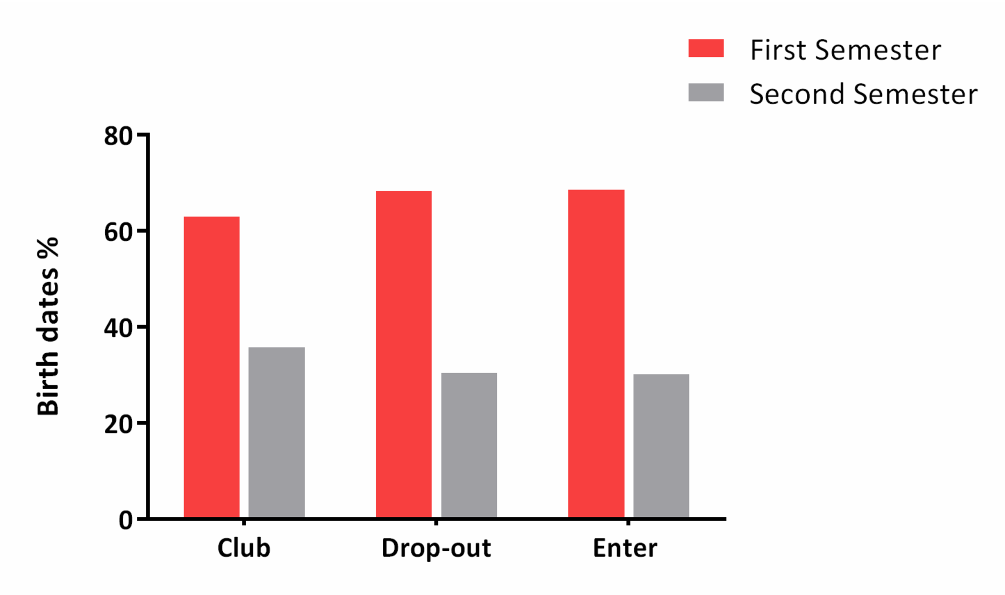


Figure 4.4.2 . Birth distribution (semesters) of Club, Drop-out and Enter players during four competitive seasons**.**

The observed unequal distribution is even more marked among the groups when analyzing birth dates by quarters (Table 4.4.17). Thereby, there was a significant predominance or players born in the first quarter among all the groups and a marked under representation of players born at the end of the year. Interestingly, as shown in Figure 4.4.3, a clear skewed distribution was observed in Enter players detecting a marked under-representation of late born ones.

Table 4.4.17. Quarterly distribution of the birth dates of soccer players by groups.

	Quarter of birth (%)				χ^2	Sig.
	First	Second	Third	Fourth		
Club	41.66	21.96	20.45	15.90	15.617	0.001
Drop-out	44.40	24.40	13.33	17.77	22.631	0.000
Enter	46.15	23.07	26.92	3.84	36.106	0.000

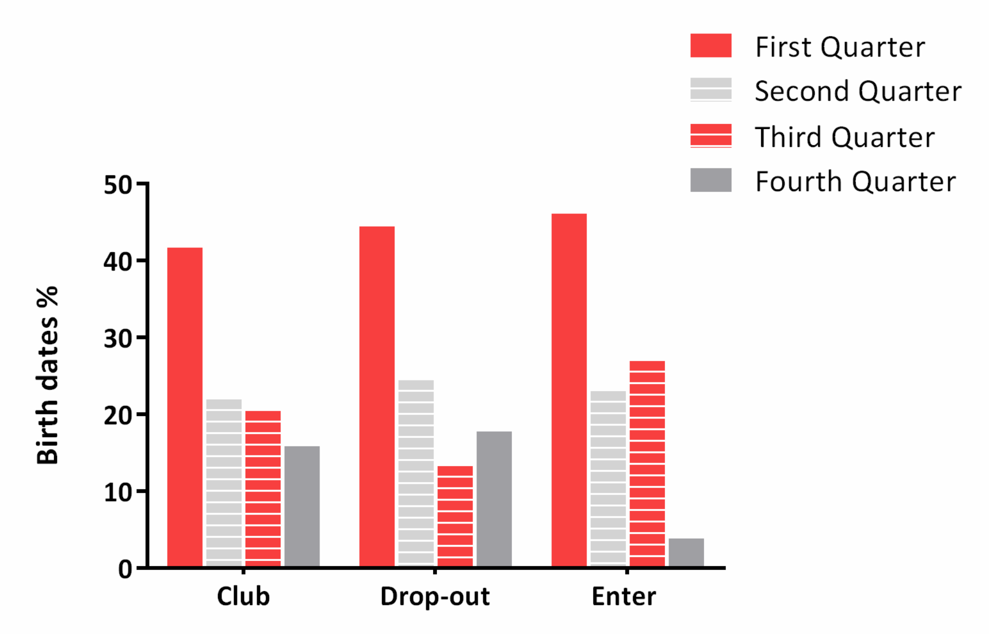


Figure 4.4.3 . Quarterly distribution of Club, Drop-out and Enter players during four competitive seasons.

4.4.4. Discussion

The purpose of the present study was to identify the factors that determine player´s potential to progress to higher levels within an elite youth soccer academy. For that aim, anthropometric and physical fitness characteristics of Club players, Drop-out players and Enter players within a youth soccer academy during three different age groups (U12, U13 and U14) were analyzed.

Growth characteristics of this sample of Basque adolescent soccer players results were consistent with other reports with heterogeneous samples of young male athletes (Malina, 1994). Therefore, among the three age groups Club players and Drop-out players mean statures ranged around the age-specific 75th percentile of Basque reference data and body masses ranged around the 50th percentile. Meanwhile, BMI ranged around the 25th and the 50th percentiles (Hernández et al., 1988). These findings are consistent with the notion that young male athletes tend to be taller than average and have body weights lower or approximate to the average (Gil et al., 2010; Gil, Ruiz, et al., 2007; Malina et al., 2011; Reilly, Bangsbo, & Franks, 2000) and it is in agreement with the importance of body size in soccer selection observed in the literature (Carling et al., 2009; Malina et al., 2000). In line with this, although Club players and Drop-out player’s anthropometric characteristics were quite similar and results were not significant, a trend was observed for Club players to be higher, heavier and to have larger circumferences and diameters than Drop-outs. Similar results have been reported elsewhere (Le Gall et al., 2010).

In the present follow-up Club players presented less amount of adiposity in all the measurement points and, therefore, they tended to be leaner than Drop-outs. Other authors have already shown the importance of fat adiposity due to its negative effect on performance in the selection of youth soccer players (Figueiredo et al., 2011; Gil, Ruiz, et al., 2007).

Interestingly, whereas Drop-out player's adiposity indicators did not almost change among the three age groups, significant changes were observed in the Club players. Indeed, there was a clear tendency in Club players to lose fat percentage in the U12 age group, gain fat in the U13 and maintain the values during the U14 season. These results observed in Club players are in agreement with the trend observed in the general population (Malina, Bouchard, & Bar-Or, 2004). However, the differences observed between the two groups are striking given that both groups were exposed to the same systematic training program. Therefore, the training program may not be the reason for losing fat in Club players. Several explanations for this problem may explain this finding. On the one hand, a possible explanation may be related to a genetic predisposition for the Club players to be leaner than their peers. On the other hand, recent research has found that sedentary behaviors predict body fatness in highly trained population regardless the amount of weekly training time (Júdice et al., 2014). Thus, presumably Club players may have more active and less sedentary behaviors which may contribute to lose fat.

In regard to physical performance, while Club players appear to perform significantly better than the Drop-outs in the youngest age groups, differences tend to disappear as age increased. Furthermore, when time effect was analyzed we found that in the youngest age group Club players showed improvements in more tests than Drop-out players. However, as age increases both groups progress equally during the season. These findings suggest, on the one hand, that in pre-pubertal ages physical tests may be helpful in the selection of players. On the other hand, it seems clear to us that as age increases players tend to achieve more homogeneous performances and, consequently, apart from performance tests other type of indicators (e.g. coordination, training experience, technical and tactical skills) should be included in the selection process in young soccer. Similar results have been previously reported elsewhere (Vandendriessche et al., 2012).

No differences were observed in maturity status between the Club players and the Drop-out players. On the one hand, this finding agree with those of Gil et al. (2014) and Carling et al. (2009) in that the lack of differences in maturity may be due to the fact that players had gone through a selection process which had produced a homogeneous sample of players. On the other hand, they contradict to some extent other studies were it has been reported that soccer systematically excludes later maturing boys (Malina et al., 2000; Philippaerts et al., 2006; Valente dos Santos, Coelho-e-Silva, Simões, et al., 2012). Certainly, comparisons to previous data merit caution as discrepancy with previous findings may be likely related to the lack of sensitiveness of the indicator of biological maturity status used (Malina, Cumming, Morano, Barron, & Miller, 2005; Malina & Koziel, 2014). Thus, more sensitive maturity indicators may need to be considered (e.g. skeletal age) in future analysis.

Regarding comparisons among Enter and Club players, Enter players appeared to be significantly higher and heavier than Club players in the U13 age group reinforcing the idea that size is an important factor associated with selection and progression in a soccer career (Gravina et al., 2008). Moreover, it seems that as age increases body size becomes more important to the extent that the new players that are selected to play in the Club are significantly taller. Interestingly, approximately 70 % of the players who entered the club (Enter players) were born in the first half of the year. Recent literature shows that children born earlier in age-based category are more likely to access higher levels of competition and to be recognized like talented (Musch & Grondin, 2001). This preference to select older players that coaches seem to show may be related with the fact that boys born in the first month of the years usually are larger, faster, jump higher and are stronger than their younger peers (Gil et al., 2014) and, therefore, are recognized like talented due to their physical superiority and selected purely because of maturity-related advantages (Mujika, Vaeyens, et al., 2009).

Thus, selection procedures that are based in anthropometric and performance control variables may eliminate late maturers with potential (Gil et al., 2014). This differentiated access to high-level training is considered as a kind of discrimination because it disadvantages players born late after the cutoff date reducing their chances to access to the elite (Delorme et al., 2010; Deprez et al., 2012; Musch & Hay, 1999).

Comparisons of fat indicators between Enter players and Club players showed that, although the values were always lower in the Club players, the Enter players tend to lose fat during the season whereas the Club players tend to maintain the values. It seems clear to us that the loss of fat observed in the Enter players may be related with an exposure to a more specific training when entering the soccer club. Thus, it seems that players who are exposed for the first time to a highly specific training program experiment a loss in fat whereas this effect is not so evident in highly selected players.

Non-significant differences were observed between Club players and Enter players in almost all the performance tests between the groups. However, although results were not statistically significant, Enter players appeared to be better in most of the performance tests at the beginning of the season. However, improvements observed in the Club players were larger than in the Enter players and, even if at the beginning of the season Enter players were better in some of the tests, results tend to homogenize at the end of the season. Thus, the Club player's improvements were larger during the season and, at the end of it they catch-up the Enter players. Besides, Enter players appeared to be significantly more mature than Club players in the U13 age group. Moreover, this difference was larger in T1 ($p < 0.01$) than in T0 ($p < 0.05$) indicating that the difference was greater when they were selected. This is in line with previous reports on youth soccer players that reported that soccer favor early maturing boys especially during adolescence (Figueiredo et al., 2009).

Given that Enter players appeared to be more mature than Club players, our results are in agreement with a study performed with 14 years old elite players were Le Gall, Carling and Reilly (2007) demonstrate that boys of advanced maturity have much less potential for growth and development and, therefore, have a reduced margin for progression compared to players who are behind maturity.

Other studies have reported that selected players may be bigger due to an early maturation process and/or genetic predisposition (Gil et al., 2010). However, mean age at peak height velocity for the different age groups (14.76 ± 0.37 years, 14.96 ± 0.42 years and 14.91 ± 0.57 years for the U12, U13 and U14 age groups, respectively) were somewhat later than estimates for the sample of the Ghent Youth Soccer Project (13.8 ± 0.8 years; Philippaerts et al., 2006) and also than the range of estimated ages at peak height velocity for samples of European boys (13.8 - 14.2 years; Malina, Bouchard, & Bar-Or, 2004). Nevertheless, when analyzing chronological age in the present study, we observed that 66 % of the players were born in the first half of the year, thereby confirming the presence of RAE (Relative Age Effect) in this group as the birth percentages for the same year of the general population were equally distributed. These results are consistent with previous studies that reported that soccer is characterized by a significant over-representation of players born in the early part of the selection year (Deprez et al., 2012; Mujika, Vaeyens, et al., 2009; Musch & Grondin, 2001) and that such a selection bias happens because of the older children possessing greater size, strength, and speed (Gil et al., 2013). Moreover, Jiménez and Pain (2008) observed that club regarded as successful from big cities and with important reputations for their youth teams are the ones strongly characterized by RAE. It is important to remember that boys of the first months of the years can be up to 10–12 months older than boys of the last ones. Therefore, differences in maturity offset between the groups may be due to differences in chronological age rather than due to maturity. In fact, it is interesting to note that there was an under-representation of players born in the last quarter of the year, being this result more dramatic in the Enter players.

The aforementioned skewed distribution revealed that the RAE acts in the early identification process of the players within the club and demonstrates that earliest levels of talent identification and selection need to be modified to provide a more equal selection process for younger players. As this regard, other authors (Baker & Logan, 2007; Barnsley et al., 1992; Musch & Gronin, 2001) have already proposed different strategies to try to avoid this uneven selection:

- <u>Classification systems based on biological age:</u> anthropometric measurements such as height, weight, or a height–weight ratio, or physiological measurements such as dental age, sexual maturity or skeletal age.
- <u>Weight categories:</u> in some sports competitive classes based on weight categories turned out to be a sensible solution.
- <u>Rotation of cut-off dates</u>: rotating cut-off dates offer a possible solution to RAE in team sports. This would have the advantage of constantly cycling the cut-off date throughout the year, thereby eliminating a systematic bias against children born late in a fixed competition year.
- <u>Calculate an average age for each group</u>: ensure that in each team there are players of both the first and the second semester.
- <u>Divide each category in two years:</u> players of the first half of the year would play together whereas players born late in the year would play together.

However, most of these resolutions are hard to achieve given that it would be difficult to find all the material and human resources required by some of the criteria. Thus, by far the first step toward ensuring equal treatment and fair competition is to bring the RAE to the attention of all coaches involved in the sports system (Musch & Gronin, 2001).

4.4.5. Conclusion

The present study showed that anthropometrical and physical performance characteristics can differentiate between players that are selected from those that are not, and provides some criteria useful for coaches and technical staff in the talent selection process within a professional soccer youth academy. Specifically, among the players that were already in the club (Club players), whereas better results in physical performance appeared to be one of the main reasons to continue in the club at younger ages, as age increased the improvement observed during the season in performance appeared to be the main reason to pass to the next category. However, different indicators appeared to be important for coaches when selecting players from other clubs. Indeed, whereas players who entered the club (Enter players) were more mature than Club players but appeared to have similar anthropometrical and physical performance characteristics, as age increased, larger body size and better performance appeared to be the main reasons for being selected. However, Club players always demonstrated better improvements during the season catching-up players who entered the club (Enter players).

CHAPTER 5

PREDICTORS OF PHYSICAL PERFORMANCE IN UNDER-12 AND UNDER-14 YOUTH ELITE BASQUE SOCCER PLAYERS

4.5. CHAPTER 5

4.5.1. Introduction

Nowadays talent identification programs are focused in the discovery of current successful soccer players, namely individuals that already demonstrate a better performance during competition than their peers (Carvalho et al., 2011). Accordingly, most talent identification programs are conducted throughout adolescence. Nevertheless, identifying talented soccer players is a multifaceted and complex process (Pearson, Naughton, & Torode, 2006). Indeed, during this period there is a considerable variation in size and performance due to biological maturation (Valente-dos-Santos, Coelho-E-Silva, Severino, et al., 2012). It is well known that the effect of growth and maturation can confound prediction of future performance. Moreover, maturation affects power, speed and the aerobic endurance of adolescent boys (Malina, Bouchard, & Bar-Or, 2004). However, even if growth and maturation are considered to be the main confounders in the prediction of future elite soccer players (Vandendriessche et al., 2012), potential interactions among maturity and performance are often overlooked as youth progress in a sport (Carvalho et al., 2011). Besides, even if the contributions of age, experience, height, body mass and maturity to indicators of functional capacities had been previously considered in a previous study carried with adolescent soccer players (Malina, Eisennman, et al., 2004) significant predictors, however, varied and greater percentages of variance were explained for some indicators than others.

To date, only a limited number of studies have tried to estimate the relative contributions of growth and maturity related variables to functional capacities. In a study performed with Portuguese national sub-elite players aged 11 - 12 and 13 - 14 years old advanced skeletal maturity and higher body weight had a positive influence in physical performance while more adiposity had a negative influence. The explained variance was greater in older (36 %) than younger (22 %) players (Figueiredo et al., 2009).

Also, in a recent study that included 88 soccer players from regional soccer clubs in the Basque Country the main contributor to variance appeared to be the amount of body fat, probably due to its negative effect on performance (Gil et al., 2014).

According to the author's knowledge the relative contributions of growth and maturation to physical performance has not yet been sufficiently explored although increasingly professional soccer clubs invest in talent development programs to detect young players able to potentially play at professional level. Thus, the present study aimed to analyze the relevance of age, body size and maturation in physical performance variables in two groups of youth soccer players: Under-12 and Under-14 years old that should give us important information about pre-pubertal and pubertal players, respectively.

4.5.2. Methodology

Study design

The cross-sectional data used for the analysis in this chapter was taken from the longitudinal study performed with youth soccer players attending the Athletic Club during the seasons 2009-2010 to 2012-2013. Specifically, measurements taken for this analysis were performed near the start of the competitive season in each age category (end of September- beginning of October) and testing took place at the same time of the day and the same external conditions. The following measurements were taken: complete anthropometry (height, body mass, sitting height and 6 skinfolds (tricipital, subescapular, suprailiacal, abdominal, thigh and leg) and physical performance tests (velocity 15-m (velocity), barrow agility test (agility), Yo-Yo intermittent recovery test (level 1) (Yo-Yo IR1), counter-movement jump (CMJ) and hand dynamometry (dynamometry). Also, age at peak height velocity (APHV) and chronological age (CA) were calculated.

Sample

The sample used for the analysis included 161 soccer players of the Athletic Club of Bilbao. Players were born in 1999 and 1998 and represented two age groups: 82 players of the Under-12 teams (U12, 11.11 ± 0.57 years of age) and 79 players of the Under-14 teams (U14, 12.80 ± 0.60 years of age). The youngest were named "*alevin*" and the eldest *"infantil"* categories in the organization of the soccer club.

Statistical Analysis

Descriptive statistics for all measures in each age group are presented as mean ± standard deviation. To determine differences between age groups Student's t-test or Wilcoxon tests were performed. The magnitude of differences or effect size (ES) were calculated according to Cohen (1988) and interpreted as small (> 0.2 and < 0.5), moderate (≥ 0.5 and < 0.8) and large (≥ 0.8).

In order to measure overall performance the results of each test were transformed into z-scores and summed up to make a total score of performance (SCORE). Thus, the SCORE was: velocity test (15-m) + agility test (barrow) + Yo-Yo IR1 + CMJ. Moreover, the SCORE was calculated with and without summing up the result of the hand dynamometry (handgrip test) (HG) ($SCORE^{HG}$ or SCORE, respectively) because strength of the upper extremity may not be directly related to performance in soccer (Gil et al., 2014).

Multiple regression analysis was conducted to estimate the relative contributions of maturity and growth variables to indicators of performance. Five predictors were entered simultaneously into the analysis: CA, APHV, sum of skinfolds (SkF), muscle percentage (musc %) and height_weight interaction (H_W Interaction).

Since height and body mass are highly interrelated, a height by body mass interaction was calculated. Thus, as proposed by Malina, Einsennman, et al., (2004) residuals (individual values minus the mean) were used in the regression. The height_weight interaction (H_W Interaction) term was derived from centered scores [(height-mean height)*(weight-mean weight)]. This method reduces the collinearity among the independent variables and consequently these are considered more stable predictors of performance.

The assumption of normality was checked by the Kolmogorov–Smirnov test with Lilliefors' significance correction. When assumptions were violated, log-transformations were performed to reduce non uniformity of error (Carvalho et al., 2011). The level of significance was set at $p < 0.05$.

4.5.3. Results

Descriptive characteristics of soccer players by age groups are summarized in Table 4.5.1. This information will not be analyzed in this chapter as characteristics of young soccer players by age group have been analyzed previously in this first chapter of this dissertation (see Chapter 1).

Results of the regression analyses in players of the U12 teams are summarized in Table 4.5.2. Sum of skinfolds accounted for 15 % of the variance in the velocity 15-m test while CA and SkF accounted for 42 % of the variance in the agility test. Meanwhile, CA, APHV and SkF were significant predictors of the Yo-Yo IR1. The three variables accounted for 41 % of the variance. Besides, SkF accounted for 16 % of the variance in the CMJ while CA and APHV accounted for 59 % of the variance in the handgrip test. Finally, in the SCORE composite, CA and SkF accounted for 30 % of the variance whilst CA, SkF and APHV were significant predictors of the $SCORE^{HG}$ composite accounting for 47 % of the variance.

Results reflect that CA appears as an important predictor in all the variables, for the exception of the velocity test and the CMJ. Similarly, SkF appears as a significant predictor in each of the performance skills except for the hand dynamometry.

Results of the regression analyses in players of the U14 teams are summarized in Table 4.5.3. H_W Interaction, SkF, and CA contributed to the variance in the velocity test accounting for 41 % of the variance. Also, SkF and CA explained 27 % of the variance in the agility test. Similarly, 30% of variance in the Yo-Yo IR1 test was explained by CA and SkF. CA, SkF and H_W Interaction explained 41 % of the variance in the CMJ. CA and APHV accounted for 40 % of the variance in the hand dynamometry. In the two composites, different variables contributed to the variance: in the SCORE composite CA, SkF and H_W Interaction explained 54 % of the variance while in the $SCORE^{HG}$ four variables contributed to 59 % of the variance: CA, muscle %, H_W Interaction and SkF. As in the youngest group, SkF and CA appeared again as performance indicators in all the performance variables. Yet, while H_W Interaction was not a predictor of performance in U12 teams, in the eldest group it explained the variance in all the performance variables except for the agility test and the Yo-Yo IR1.

Table 4.5.1. Descriptive characteristic of soccer players by age group.

	Under-12 (N=82) Mean ± sd	Under-14 (N=79) Mean ± sd	Cohen´s d	*r*
CA (years)	11.11 ± 0.57***	12.80 ± 0.59	-2.91	-0.82
Maturity offset (years)	-3.38 ± 0.46***	-2.17 ± 0.71	-2.02	-0.71
APHV (years)	14.51 ± 0.38***	14.94 ± 0.56	-0.89	-0.40
Body mass (kg)	7.97 ± 5.33***	46.10 ± 8.24	-1.17	-0.50
Height (cm)	146.38 ± 6.29***	157.43 ± 8.64	-1.46	-0.59
Sitting height (cm)	121.99 ± 3.31***	126.75 ± 4.48	-1.20	-0.51
BMI (kg/cm^2)	17.64 ± 1.45**	18.45 ± 1.59	-0.53	-0.25
Sum of skinfolds (mm)	56.84 ± 22.35*	50.28 ± 14.00	0.35	0.17
Fat %	10.37 ± 2.06	9.99 ± 1.39	0.21	0.10
Musc %	46.92 ± 1.87**	46.09 ± 1.22	0.52	0.25
Velocity 15-m (s)	5.93 ± 0.24***	6.36 ± 0.33	-1.49	-0.59
Agility (s)	2.06 ± 0.09***	2.19 ± 0.09	-1.44	-0.58
Yo-Yo IR1 (m)	906.92 ± 324.06***	1274.10 ± 297.35	-1.18	-0.50
CMJ (cm)	33.21 ± 4.62***	36.06 ± 4.66	-0.61	-0.29
HG (kp)	22.11 ± 5.35***	29.03 ± 5.59	-1.26	-0.53
SCORE	-1.46 ± 2.39***	2.06 ± 2.29	-1.50	-0.60
SCORE^{HG}	-1.98 ± 2.91***	2.57 ± 2.95	-0.20	-0.10

CA: Chronological age; APHV: Age at peak height velocity; BMI: Body mass index; Yo-Yo IR1, Yo-Yo intermittent recovery test (Level 1); CMJ, counter-movement jump test; HG: hand dynamometry; SCORE: velocity test (15-m) + agility test (barrow) + Yo-Yo IR1 + CMJ; SCORE^{HG}: velocity test (15-m) + agility test (barrow) + Yo-Yo IR1 + CMJ+ HG. $^{*}p< 0.05$; $^{**}p< 0.01$; $^{***}p< 0.001$.

Table 4.5.2. Multiple stepwise regression analysis of the performance variables and the selected predictor variables in Under-12 soccer players.

Dependent variables	Predictor variables	β	p	R^2	R^2 Change	F (sig.)
Velocity	SkF	0.397	<0.001	0.158	0.158	12.554**
Agility	CA	0.527	<0.001	0.234	0.234	20.512***
	CA, SkF	0.436	<0.001	0.422	0.188	24.141***
Yo-Yo IR1	CA	0.803	<0.001	0.255	0.255	17.133***
	CA, APHV	0.438	<0.01	0.351	0.095	13.226***
	CA, APHV, SkF	0.253	<0.05	0.413	0.062	11.254***
CMJ	SkF	0.409	<0.001	0.168	0.168	13.483***
	CA	0.881	<0.001	0.554	0.554	88.058***
HG	CA, APHV	0.241	<0.05	0.593	0.039	51.018***
	CA,	0.452	<0.001	0.173	0.173	10.425***
SCORE	CA, SkF	0.367	<0.01	0.306	0.133	10.789***
	CA	0.801	<0.001	0.325	0.325	23.061***
$SCORE^{HG}$	CA, SkF	0.323	<0.01	0.407	0.082	16.112***
	CA, SkF, APHV	0.344	<0.05	0.475	0.068	13.877***

CA: chronological age; SkF: sum of skinfolds (triceps, subscapular, abdominal, suprailiac, thigh and calf); APHV: age at peak height velocity; Yo-Yo IR1: Yo-Yo intermittent recovery test (Level 1); CMJ: counter-movement jump; HG: hand dynamometry; SCORE: velocity (15-m) + agility + Yo-Yo IR1 + CMJ; $SCORE^{HG}$: velocity test (15-m) + agility test (barrow) + Yo-Yo IR1 + CMJ+ HG.

**p< 0.01; ***p< 0.001.

Table 4.5.3. Multiple stepwise regression analysis of the performance variables and the selected predictor variables in the Under-14 soccer players.

Dependent variables	Predictor variables	β	p	R^2	R^2 Change	F (sig.)
Velocity	H_W Interaction	0.448	<0.001	0.176	0.176	12.211**
	H_W Interaction, SkF	0.389	<0.001	0.338	0.161	14.279***
	H_W Interaction, SkF, CA	0.291	<0.001	0.419	0.081	13.222***
Agility	SkF	0.426	<0.001	0.190	0.190	13.359**
	SkF , CA	0.283	<0.05	0.270	0.080	10.360***
Yo-Yo IR1	CA	0.410	<0.001	0.179	0.179	10.252**
	CA, SkF	0.348	<0.001	0.300	0.121	9.845***
CMJ	CA	0.308	<0.001	0.165	0.165	10.845**
	CA, SkF	0.446	<0.001	0.295	0.130	11.277***
	CA, SkF, H_W Interaction	0.362	<0.001	0.413	0.118	12.432***
HG	CA	0.553	<0.001	0.155	0.155	10.254**
	CA, APHV	0.522	<0.001	0.402	0.247	18.464***
SCORE	CA	0.504	<0.001	0.322	0.322	21.830***
	CA, SkF	0.489	<0.001	0.462	0.140	19.290***
	CA, SkF, H_W Interaction	0.315	<0.001	0.545	0.083	17.572***
$SCORE^{HG}$	CA	0.521	<0.001	0.356	0.356	23.229***
	CA, Musc %	0.258	<0.05	0.489	0.133	19.651***
	CA, Musc %, H_W Interaction	0.338	<0.001	0.540	0.051	15.674***
	CA, Musc %, H_W Interaction, SkF	0.292	<0.05	0.597	0.057	14.448***

H_W Interaction: height_weight interaction; CA: chronological age; SkF: sum of skinfolds (triceps, subscapular, abdominal, suprailiac, thigh and calf); APHV: age at peak height velocity; Yo-Yo IR1: Yo-Yo intermittent recovery test (level 1); CMJ: counter-movement jump; HG: hand dynamometry; SCORE: velocity (15-m) + agility + Yo-Yo IR1 + CMJ; $SCORE^{HG}$: velocity test (15-m) + agility test (barrow) + Yo-Yo IR1 + CMJ+ HG.

**p< 0.01; ***p< 0.001.

4.5.4. Discussion

In this study, the contribution of chronological age (CA), age at peak height velocity (APHV), height_weight interaction (H_W interaction), subcutaneous adiposity and muscle % to physical performance indicators among young elite soccer players of different age groups were considered.

Mean statures and body masses ranged around the age-specific 75th and 50th percentiles of Basque reference data, respectively (Hernandez et al., 1988). As a result, mean BMIs were slightly below age-specific reference medians. This is consistent with the notion that young male athletes tend to be taller than average and to have body weights that approximate the average; hence, they tend to have less weight-for-height (Malina et al., 2011). The variability in size reflected in part the selective demands of soccer and probably advanced maturity status. Indeed, due to the particular selection philosophy of the Athletic Club, that dictates that players within the club have to be either born or developed in the Basque Country, players can be considered as highly selected. Thus, the trend observed in body size is consistent with results obtained in other studies were body size appeared to be important for soccer selection (Malina et al., 2000) and with the well-known notion that selection in youth soccer tends to favor players with advanced maturity status that are taller and heavier and demonstrate better performance in physical tests than their younger peers (Gil et al., 2014).

Although our results are in line with previous studies, limited data are available on the development of talented young soccer players. In a previous study with youth Portuguese soccer players aged 11-12 and 13-14 years, predictors of functional capacities and skills differed between age groups except in CMJ where predictors were the same (Figueiredo et al., 2009). Similarly, in the current study, the predictors of older players were different compared to those in younger players in all the physical performance variables except for agility and handgrip tests.

In addition, whereas explained variance was greater in the U14 players in velocity, CMJ, SCORE and SCORE^{HG}, variance was greater in the U12 players in agility, Yo-Yo IR1 and handgrip. These differences observed among the age groups may be related to different timing of growth spurts in power, speed and endurance (Malina, Bouchard, & Bar-Or, 2004).

Of all the variables included, CA was one of the main predictors. Indeed, CA explained variance in all the indicators of physical performance in both age groups except for velocity and CMJ in the U12 group. CA, due to its influence on the maturation of the nervous system including changes in the cerebral cortex and neural pathways associated with motor function (Malina, Bouchard, & Bar-Or, 2004), may have an important influence in performance during adolescence (Beunen & Malina, 1988). Similarly, it has been reported that CA is a more important predictor than age at peak height velocity during the first selection throughout a selection process of hockey players (Sherar et al., 2007).

Sum of skinfolds was included among the predictors in all the physical performance variables except for handgrip in the U12 and the U14 age groups and had a negative influence in all of them. Evidence drawn from other studies had already showed that boys in higher BMI quartiles demonstrated reduced physical fitness compared with those in the lower quartiles (Gil et al., 2014; Nikolaidis, 2012a). Moreover, Nikolaidis (2012b) concluded that it seems that overweight affects young soccer players in a similar extent as it does in general population. More specifically, in a study performed with young Spanish soccer players, authors observed that skinfold thickness had a negative influence on a 500 m run and 60 m dash (Feliu Rovira et al., 1991). Besides, in 13-14 year old Portuguese soccer players, the negative influence of excess of body fat on aerobic endurance has also been previously highlighted (Figueiredo et al., 2009).

Similar amounts of the variance in velocity 15-m and in CMJ were explained by the independent variables in both age groups: 15 % and 41 % of the variance for the U12 and the U14 age groups, respectively. Sum of skinfolds contributed negatively to the variance in the velocity 15-m and the CMJ in the U12 group whereas H_W interaction, SkF and CA explained the variance of both tests in the U14 age group. Consequently, the positive influence of CA and H_W interaction and negative effect of sum of skinfolds suggested that older, bigger and leaner players had better performances in the velocity and the CMJ tests.

In line with our results, various studies have revealed that players that perform better over short distances tend to have a lower percentage of body fat (Huijgen, Elferink-Gemser, Post, & Visscher, 2010; Reilly, Williams, et al., 2000). Moreover, research has shown that lower percentage of body fat means more lean body mass and, therefore, more muscle mass which has an influence on speed over short distances (Huijgen et al., 2010). Also, cross-sectional research on talented youth soccer players has reported improvements in sprinting tests with age (Gil, Gil, et al., 2007; Vanderford, Meyers, Skelly, Stewart, & Hamilton, 2004). Nevertheless, the process of maturation does not occur at the same chronological age for all talented soccer players, possibly influencing the performance of individual players since advanced biological maturity status is associated with better performance (Malina, Cumming, Kontos, et al., 2005). Moreover, it has been suggested that sprint ability improves during maturation of highly trained youth soccer players (Mujika, Spencer, et al., 2009). By this means, players with the same CA but who are biologically advanced tend to be, on average, taller and heavier than those players who are classified as delayed (Malina, Ribeiro, et al., 2007).

Likewise, previous research also showed height to be a significant predictor for running speed and vertical jump in a talented group of young soccer players (Malina, Eisennman, et al., 2004). Indeed, in a study that examined growth rates in running speed and vertical jump among middle school children the growth rate for vertical jump was positively associated with height (Butterfield, Lenhard, Lee, & Coladarci, 2004).

Thus, this is in agreement with the findings in the current study that illustrates that H_W interaction can determine performance in older players in velocity 15-m and CMJ tests. Interestingly, results observed in a study carried by Moreira et al. (2013) in a group of forty five young Brazilian soccer players of the U12 and the U13 categories revealed that salivary testosterone concentration was the main contributor of the variance for the vertical jump performance (Moreira et al., 2013). Certainly, it is well known that testosterone contributes muscle growth and improves strength-related performance (Baldari et al., 2009). Although salivary testosterone concentration was not analyzed in the current study, the contribution of H_W interaction to counter-movement jump may be associated with gains in testosterone concentration that occur as ages increases (Hansen et al., 1999).

Regarding the agility tests, the regression models explained only 42 % and 27 % of the variance in the U12 and U14 players, respectively. CA and sum of skinfolds were the significant predictors identified in the stepwise regression models in both age groups. CA, due to its influence of the nervous system, may have an important influence on more complex tasks in which coordination is important, such as in the agility test (Huijgen et al., 2010). In contrast to the other performance indicators, predictors explained greater variance in the agility test in the younger age group than in the older age group. Allowing for protocol differences, the results are consistent with previous observations in youth soccer (Huijgen et al., 2010; Pearson et al., 2006). On the one hand, it seems logical to believe that older players had been more years training in the club. Thus, previous experience with the protocol procedure may have contributed to the higher homogeneity of the results since the test is often used in the soccer academy. On the other hand, earlier research has suggested that in the early years of development (up to puberty) a greater change exits in development of motor skills than after puberty (Reilly, Williams, et al., 2000).

Nevertheless, as agility is a result of a number of neurophysiological factors, it is difficult to determine exactly which factors contribute to a changed result on a test (Buttifant et al., 2002). Although no direct measurement was made to determine metabolic profile of the agility test, the duration of the protocol and association with short-term maximal performance suggests that the test may have a high anaerobic contribution. Anaerobic ATP production during single short-duration maximal efforts (< 10s) is provided by considerable contributions from both phosphorylcreatine degradation and anaerobic glycolysis (Dawson et al., 1997). As short-term maximal performance tends to be lower in children than adolescents and adults and it has been suggested that limitations of glycolysis, phosphorylcreatine breakdown, and oxidative re-phosphorylisation confines performance throughout pubertal development (Beneke et al., 2007). Thus, potentially confounding factors in explaining the determinants of agility performance in adolescent soccer players may include maturity-related variation in short-term muscle power outputs (Carvalho et al., 2011).

In relation to Yo-Yo IR1, whereas CA, APHV and SkF explained 41 % of the variance in the younger group, the contribution of APHV disappeared in the older group and the outstanding variables explained 30 % of the variance. Previous longitudinal studies in males revealed that the greatest improvement in aerobic capacity occurs between the ages of 11 and 15 years (Pearson et al., 2006). Specifically, in a study carried with a random sample of 453 coach-nominated athletes (231 boys and 222 girls) from four sports (gymnastics, soccer, swimming, and tennis), Nevill et al. (1998) observed that the aerobic power of the male and female young athletes was increasing at a greater proportion of their body size at 12 years of age. Indeed, at 12 years of age, post pubertal boys had greater levels of aerobic power than pre pubertal boys, indicating that biological age as well as chronological age was an important factor in the development of aerobic power. This is in agreement with the results obtained in the current study were CA and APHV appeared to be one of the main predictors of the endurance run test in the younger groups.

.

When handgrip test was analyzed, the independent variables remained the same in both aged groups: CA and APHV contributed to the 59 % and the 40 % of the variance in the U12 and the U14 age groups, respectively. These results are in contrast with other studies that observed that the maximal isometric strength exerted by the forearm muscles in humans is proportional to their size irrespective of age (Tonson, Ratel, Le Fur, Cozzone, & Bendahan, 2008). It is interesting to note that in the overall SCORE in the younger group, APHV appeared to contribute to the variance when the handgrip test was included, reinforcing the influence of maturation and CA on handgrip test strength and, subsequently, on the $SCORE^{HG}$. Similar results were observed in the older age group. Precisely, muscle percentage appeared to contribute to the variance in $SCORE^{HG}$ when the handgrip test was included.

4.5.5. Conclusion

In summary, chronological age, maturity status, size and adiposity contribute to the explained variance in a variety of functional indicators in adolescent youth soccer players. Predictors of performance differed between age groups except for velocity and CMJ. Also, except for the agility, predictors explained greater variance in older players in the Yo-Yo IR1 and handgrip test. CA entered almost all indicators in both age groups. Thus, CA due to its influence on the maturation may have an important influence in performance during adolescence (Beunen & Malina, 1988). Hence, the results highlight the significant role of individual differences in biological maturity status in the functional capacity of adolescent football players.

However, the present study is limited to offer a clear interpretation of somatic maturity status due to possible limitations of the maturity indicator and the ethnic variability in biological maturation due to the specificity of the sample. Definitely, the maturity offset protocol to predict age at PHV may not be a sufficiently sensitive indicator of biological maturity status (Malina & Koziel, 2014). Thus, more sensitive maturity indicators may need to be considered in future analysis.

5. General discussion

5. GENERAL DISCUSSION

The interest of talent identification, selection and development by researches has risen considerable in the last decade. In this way, clubs have developed a variety of programs in order search for the best players to detect those players who will have the potential to progress to professional level. Although it has been recommended multidimensional approaches to study talent identification and development in sport (Reilly et al., 2000), the factors that identify players who achieve to progress to the highest level remain unknown.

The cross-sectional studies developed in Chapter 1 and 2 provide useful and comprehensible data for coaching staff regarding the expected anthropometrical, physical performance and maturational characteristics of highly selected youth soccer players in different age categories. This issue becomes more important in the Club investigated in the present study. Indeed, due to its recruiting policy which states that all players need to be either born or developed in the Basque Country, selection is made in a rather small pool of youths. Thus, the knowledge of a more specific profile in each of the age groups will help coaches when improving the development in a highly selective context, as well as for technical staff in the talent identification processes.

In regards to the aforementioned profile, results showed that older players were higher, heavier and have larger diameters and circumferences than younger players in the club. In addition, players were clearly larger than their age matched counterparts not engaged in soccer, players of local clubs and *DENA* project players. However, this may be due to a selection process towards larger and stronger boys. Moreover, results observed in Chapter 4 supports this hypothesis. Indeed, as age increased, larger body size appeared to be one the main reasons for players being selected to play in the club.

Thus, the results of this study are in agreement with the hypothesis that soccer coaches believe that in young categories an anthropometrical advantage is a benefit, making them select players with a specific body type (Gil et al., 2010; Wong et al., 2009). However, in contrast with the notion that larger size is an important factor associated with progression in a soccer career (Figueiredo et al., 2009; Le Gall et al., 2010), it was interesting to observe that larger body size per se was not the main the factor to progress to higher categories in the club. Thus, it seems clear to the authors that, even if body size appears to be one of the main reasons to be selected to play in the club, it is not the main reason to continue in the club and progress to higher categories.

With regard to selection and progression within the club, fat adiposity was also an interesting parameter to consider. In this respect, the average fat percentage of the Athletic Club soccer players was appropriate for their level and age, which is around 10-12 % (Nikolaidis, 2012a; Gil et al., 2010). Interestingly, although differences between age groups were not observed, the distribution of fat changed as age increased in agreement with what has been previously observed in the general population (Malina, Bouchard, & Bar-Or, 2004). Additionally, when comparing different populations, Athletic Club players and the *DENA* players appeared to have smaller fat adiposity values. Moreover, as age increased Athletic Club players had significantly less amount of fat than the *DENA* players. On the one hand, it seems clear to the authors that as age increases selection becomes more difficult and, therefore, players with less amount of fat may be chosen to play at higher levels (Figueiredo et al., 2011). On the other hand, these results support the idea that fat adiposity affects negatively to performance. These findings are supported by results observed when comparing Club players, Drop-out players and Enter players (Chapter 4).

Certainly, results showed that Club players presented less fat adiposity and tended to be leaner. Also, a clear tendency for Club players to lose fat percentage during the season was observed, supporting the idea that leaner players achieve to progress to higher levels. However, it was striking to find this result, as Drop-out players and players who continued in the club were exposed to the same systematic training program.

Regarding the somatotype, in agreement with previous literature (Gil et al, 2010; Mirkov, Kukolj, Ugarkovic, Koprivica, & Jaric, 2010; Rienzi et al., 2000) results showed that mesomorphy was the major component in Athletic Club soccer players. Conversely, Local players and the General Population presented higher levels of endomorphy confirming that high-level soccer players had lower endomorphy scores than the general population (Gil et al., 2010).

Despite multidimensional approaches, the focus of the studies in young athletes is mostly on anthropometrical characteristics and physical performance, but the consideration of confounding effects introduced my maturation have not been sufficiently considered (Pearson et al., 2006). Given that longitudinal approaches may provide far greater insights into the development of performance variables, we used a mixed cross-sectional and longitudinal approach to observe the changes in development in elite young soccer players during a period of 4 competitive seasons (Chapter 3). The results observed agree with those of previous authors (Le Gall et al., 2010; Mirkov et al., 2010) in that performance characteristics vary according to player's age. Although all parameters showed significant improvements in performance with age, improvements of performance capacities showed periods of accelerated development.

Throughout the follow-up, velocity 15-m performance appears to be quite stable until a peak of development was observed between U13 and U14 seasons, which are in agreement with the results observed for both general population and youth soccer players (Malina, Bouchard, & Bar-Or, 2004; Philippaerts et al., 2006; Vänttinen et al., 2010). This increase in velocity observed may be related to adolescent spurts in body dimension that occurs on average shortly before peak height velocity (Beunen & Malina, 1988; Malina, Bouchard, & Bar-Or, 2004).

Similarly, the changes observed in the counter-movement jump showed, on the one hand, an important decrement during the U11 season that may be related to disrupting motor coordination due to accelerated physical growth (Philippaerts et al., 2006; Williams et al., 2011) and, on the other hand, a peak gain in performance at the age of around 13 years, coincident with peak height velocity (Philippaerts et al., 2006). However, the small improvements observed in the jump tests over the four seasons suggest that stimulation of jumping in soccer training may be limited. Consequently, coaches may need to consider alternative training to promote the development of jumping in soccer (Sedano, Matheu, Redondo, & Cuadrado, 2011; Thomas, French, & Hayes, 2009).

In regard to agility, our results showed that the highest change rates happened in the U11 season and, afterwards, the rates seem to plateau. Thus, we may conclude that the fastest development in agility occurs during pre-puberty (Malina, Bouchard, & Bar-Or, 2004). However, a peak of improvement was observed in the U13 season that may be partially attributed to linear growth and gains in muscle mass with pubertal growth. Lastly, as older players with more experience attained better results it seems logical to deduce that the magnitude of improvement in agility may be influenced by the training status or age of the players (Sheppard & Young, 2006).

Concerning Yo-Yo IR1 performance, observed changes during the follow-up indicated that improvements were higher than changes observed in the rest of the tests. Nevertheless, while improvements appeared to be more pronounced in the U11, U13 and U14 seasons, in all the between seasons measurements the change percentages tend to decrease. Thus, results may indicate that development of the Yo-Yo IR1 possibly will be positively influenced by systematic training exposure. This is in agreement with the idea that soccer-specific training over the season in adolescent years may affect positively intermittent endurance training (Hammami et al., 2013).

During the follow-up results showed differences in the rate of improvements in the handgrip test. Specifically, linear increases in handgrip occurred up to age 13-14 years old after which the development of handgrip accelerated. These results may be related to peak gains in handgrip that are coincident with peak height velocity and that are probably related to the adolescent spurt in muscle mass that occurs shortly after peak height velocity (Butterfield, Lehnhard, Loovis, Coladarci, & Saucier, 2009; Philippaerts et al., 2006).

In addition, when analyzing more closely the performance changes during the off-season periods, we found that player's performance improved in the youngest ages, in contrast with what has been previously reported in the literature (Mechiorri et al., 2014). Nonetheless, in the U13 off-season an evident decrement was observed in most of the performance parameters. Thus, on the one hand, while it seems logical to think that the improvements observed in the youngest ages may be related to improvements associated to growth and maturation, the decrement observed in the U13 off-season may be explained by the effect of partial physiological loss of training adaptations due to reduction of training during the summer that may affect more to the youth soccer players as they get older.

Altogether, the aforementioned information about performance development during adolescence can be valuable to coaches and technical staff by providing them with a better understanding of expected changes during this period. Moreover, in Chapter 4, when Club players and Drop-out players were compared, performance and, specifically improvements in certain parameters, appeared to differentiate between players that are selected from those that were not. In pre-pubertal ages data indicated that physical tests may be helpful in the selection of players. Likewise, when analyzing differences between Club players and Enter players, although Enter players appeared to be better in most of the performance tests at the beginning of the season improvements in the Club players were larger and in the end of the season they tend to catch up Enter players.

We have already demonstrated that the information about changes during adolescence can improve insight into the development of a specific group and can assist in an appropriate talent development program design. However, growth and maturation are considered to be the main confounders in the prediction of future elite soccer players (Vandendriessche et al., 2012). Therefore, to give further insight to this issue, the contribution of CA, age at peak height velocity (APHV), height_weight interaction, subcutaneous adiposity and muscle % to physical performance indicators were considered in Chapter 5. Summarizing, CA, maturity status, size and adiposity appeared to contribute to the explained variance of the performance indicators in adolescent youth soccer players (from the Under-12 and the Under-14 categories). Although predictors of performance differed between age groups, CA and sum of skinfolds entered almost all indicators. Thus, it seems clear that CA may have an important influence in performance during adolescence (Beunen & Malina, 1988). This is in line with results observed in Chapter 4. Indeed, when analyzing CA among Club players, Drop-out players and Enter players, we observed that 66 % of the players were born in the first half of the year, confirming a significant over-representation in the Club of players born in the early part of the selection year and, therefore, the presence of the Relative Age Effect (RAE).

Such a selection bias may be related with the well-known influence of CA in maturation (Malina, Cumming, Kontos, et al., 2005; Sherar et al., 2007) and the fact that youth soccer tends to favor players with advanced maturity status that posses greater size, strength, and speed than their younger peers (Deprez et al., 2013; Gil et al., 2014; Musch & Gronin, 2001). Moreover, it was striking to observe that there was a dramatic under-representation of players born in the last quarter of the year indicating that players born late in the selection year have fewer opportunities to be selected to play in the club (Musch & Hay, 1999).

Overall, it seems clear that the development of a youth soccer players towards a professional career is a long process. By these means, the results observed in the present dissertation highlights the significant role of individual differences in adolescence in anthropometrical, physical fitness and maturational characteristics in youth elite soccer players and the need to implement multidisciplinary but individualized scenarios for a better selection, identification and development of the future professional soccer players.

6. Main conclusions

6. MAIN CONCLUSIONS

The current thesis research has gained greater understanding into the talent development and selection process of young soccer players by examining the development of anthropometrical, physiological and maturation parameters around puberty and its related factors influencing the soccer performance.

As such, it is possible to summarize the present thesis research in a short number of main conclusions:

1. The analysis of different parameters amongst adolescent players of the Athletic Club showed that players grow as age increased and, similarly, performance improvements were observed in speed, agility, vertical jump endurance and strength. Thus, the patterns of physical growth and maturation of young players merit more detailed consideration when analyzing performance in young soccer players.

2. Besides, several differences in anthropometrical characteristics were observed when comparing different adolescent populations. Overall, Athletic Club players showed a tendency to be larger and leaner than the general Basque population and soccer players of lower level. It seems clear that a large body size and a small amount of body fat are relevant anthropometric parameters involved in the selection process of high level soccer players.

3. Although improvements in performance were observed as age increase, periods of accelerated development were observed. Specifically, larger rates of growth and performance improvements were observed in the U13 and U14 ages in velocity, endurance, vertical jump and strength, coincident with peak height velocity. In contrast, the fastest development in agility occurred during the youngest ages. Thus, the results indicate that changes in performance were significantly affected by growth and maturation. This information can be valuable to coaches and technical staff by providing them with a better understanding of expected changes during these different periods.

4. Interestingly, improvements in velocity, agility, endurance, vertical jump and strength were observed in most of the off-season periods, possibly due to the effects of body growth. However, an evident decrement in performance was observed in the U13 off-season indicating a possible effect of detraining due to the summer vacation at this age. It is important that this finding is confirmed in more similar studies in the future. Should it be verified it would be interesting to implement a protocol during the off-season to avoid the observed decrement in performance.

5. When analyzing selection and progression within the club, whereas players who continued in the club and players who did not appeared to be anthropometrically similar, players of the club performed better than those that left the club. However, as age increased, differences become smaller. Thus, it seems clear that anthropometrical and physical performance characteristics can differentiate between players that are selected from those that are not, and provides some criteria useful for coaches and technical staff in the talent selection process within a professional soccer youth academy.

6. In addition, players who entered the club appeared to be significantly taller and heavier than players within the club as age increased, indicating that in older categories body size becomes more important in the selection process. Also, players who entered the club appeared to be better in most of the performance tests at the beginning of the season. Moreover, they were more mature. Indeed, results demonstrate that these procesures may eliminate late maturers wih potential and exclude players born late reducing their chances to access to the elite.

7. Sixty six percent of the players were born in the first half of the year confirming the presence of the Relative Age Effect in the club. Moreover, approximately seventy percent of players who entered the club were born in the first half of the year and there was a significant under-representation of players born in the last quarter among them. Hence, chronological age plays a significant role in the selection process of high level young soccer players as it has been observed in other sports, favoring the selection of ayers born in the beginning of the year and preventing the selection of the youngest players.

8. When analyzing performance predictors, chronological age, maturity status, body size and fat adiposity appeared to contribute to the variance of the performance indicators. Moreover, chronological age and sum of skinfolds appeared to be the main predictors of performance. This may be the reason for the technical staff of the club to select players with a large body size, advanced maturity, particularly older chronological age and less body fat, who are by far the best performers at younger ages. However, it is difficult to know if they will achieve a professional soccer level in the future. Furthermore, technical staff should be aware of the fact that the selection process excludes potentially talented players that are younger, smaller and lighter during the talent identification process who are not be given the opportunity to develop their full talent.

7. Limitations and future research

7. LIMITATIONS OF THE STUDY AND FUTURE RESEARCH

7.1. Limitations of the study

The current thesis research has gained greater insight into the talent development and selection process of young soccer players by examining the development of anthropometrical, physiological and maturation parameters and its related factors influencing soccer performance. However, although the present data should be utilized within the talent development programs, the authors acknowledge that such characteristics by their own may not lead to future progress to professional status in soccer. Moreover, other components like sport specific skills, quality and quantity of training, cognitive, psychological, and social factors that, unfortunately, have not been analyzed in the present study, may be important to success in soccer (Vänttinen, 2013).

Several other limitations associated with this study should be noted. In the present study we measured many of the variables that have been suggested to measure when monitoring long-term development in young soccer players (Reilly et al., 2000; Vaeyens et al., 2006). Moreover, regarding the methods, the study trusted mainly the measurement protocols and field tests which have a long tradition in soccer (Bangsbo et al., 2008; Baxter-Jones et al., 2005; Chamari et al., 2004; Reilly & Thomas, 1977; Sheppard & Young, 2006; Svensson & Drust, 2005; Vänttinen, 2013). However, although field tests can be an effective procedure to reveal comprehensive and suitable evaluation of young soccer players because of their simplicity and lack of equipment (Chamari et al., 2004), with the present data set it is not possible to ascertain whether the observed trends reflects only continued growth and maturation or/and perhaps an interaction with the influence of systematic sport training.

Thus, a complete record of the applied training load and activities may have provided valuable feedback and information about the impact of training on performance. As a consequence, further study should include data on the intensity and duration of the exercises and sessions in youth soccer players (Jastrzębski, Rompa, Szutowicz, & Radzimiński, 2013).

The agility test used in the present study reflects another limitation of the study. A ‘‘gold standard’’ reference for agility testing in soccer players has not been yet established and, therefore, the interpretations and comparisons of agility performance are limited as different tests may examine different factors associated to performance (Sheppard & Young, 2006). Additionally, it is important to note that the agility test used in the current analysis, the Barrow tests, was routinely repeated at intervals of 4-5 months in the field testing session within the club. As such, results may have been influenced by the fact that players may improve their performance due to a learning process. Nevertheless, in a previous analysis performed with a sub-sample of 51 youth soccer players, 24 players of the under-11 and 27 players from the under-13 age groups, the agility test demonstrated high reliability and acceptable validity to measure changes in performance.

Another limitation concerning the results of the study arises from the interpretation of somatic maturity status, due to possible lack of sensitiveness of the maturity indicator. APHV estimates have appeared to be a potential alternative to measure maturity status (Mirwald et al., 2002; Philippaerts et al., 2006). However, Malina and Koziel (2014) observed in a sample of Polish boys that APHV was underestimated (earlier than the actual APHV) at younger ages and overestimated (later than actual APHV) at older ages. Moreover, differences between predicted and actual APHV were especially apparent at 8-11 years of age.

As such, authors recommended that the maturity offset should not be used at these ages in boys. Given the aforementioned limitations, the maturity offset protocol to predict age at PHV may not be a sufficiently sensitive indicator of biological maturity status in the present sample of youth soccer players aged 11-15 years old. Consequently, more sensitive maturity indicators may need to be considered (e.g. skeletal age) in future analysis.

An additional potential methodological limitation was related with hormone concentration. Indeed, hormone analyses were based on a single sample which is not optimal due to the episodic secretion pattern of hormones (Granger et al., 2004). Furthermore, the daily rhythm of testosterone and DHEA is associated with higher levels in the morning (Di Luigi et al., 2006; Whetzel & Klein, 2010). As such, we cannot exclude the possibility that our results might have been different if the evaluations had been performed during the morning. However, all the samples were taken at the same time of the day and all the testing conditions were standardized including hydration and pre-assessment food intake.

Finally, regarding the sample used in this dissertation, although data from goalkeepers was recorded during the 4 year follow-up, they were excluded from the analysis and, as a result, only outfield players were analyzed. Indeed, goalkeepers had especially distinct anthropometrical and physical characteristics in comparison to the outfield players (Di Salvo et al., 2007; Ziv & Lidor, 2011) and these differences may have affected the statistical analysis. However, goalkeepers are necessarily part of the team and, therefore, of the talent identification and selection process. Thus, a complete scenario of the talent identification process in youth soccer players may be incomplete when goalkeepers are not taken into account.

7.2. Future research

From the studies in the current dissertation practical implications for trainers, coaches, players can be derived. However, given the aforementioned limitations, future research should investigate several issues.

Firstly, there is less information in the literature about soccer goalkeepers compared to the information about other positions. Moreover, longitudinal data concerning goalkeepers' development is scarce. Therefore, to provide a complete scenario of the talent identification and development of youth soccer players, a longitudinal approach of goalkeepers´ selection is needed.

Secondly, in the present study the development of anthropometrical, physiological and maturation parameters and its related factors influencing the soccer performance have been analyzed. However, these characteristics by their own may not lead to success and, therefore, other components may be important to success in soccer. Thus, future research should take into account psychological components, technical and tactical skills, training load, social factor and soccer specific skills among others. Moreover, future research should focus on a longitudinal approach of the mentioned components.

By this means, it is important to underline the important role of longitudinal data in the talent identification and selection process. Although in the present study a mixed cross-sectional and longitudinal approach has been performed, future research should focus on measuring similar parameters during a larger period to analyze the profile of soccer players that achieve to play in the highest level. Definitely, this data would help to predict the potential of players and, therefore, be very interesting for talent selection and development.

Finally, there is limited available data as regard to the selection and talent identification processes among female soccer players. Furthermore, hardly any information exists concerning longitudinal approaches in women soccer. Thus, it will be really interesting to measure similar parameters in youth female soccer players in order to recognize the rationale behind the talent identification and selection in women.

8. References

8. REFERENCES

Armstrong, N., Welsman, J.R., Nevill, A.M., & Kirby, B.J. (1999). Modeling growth and maturation changes in peak oxygen uptake in 11-13 yr olds. *Journal of Applied Physiology*, *87*(6), 2230-2236.

Arnason, A., Sigurdsson, S.B., Gudmundsson, A., Holme, I., Engebretsen, L., & Bahr, R. (2004). Physical fitness, injuries, and team performance in soccer. *Medicine and Science in Sports and Exercise*, *36*(2), 278-285.

Baker, J., & Logan, A.J. (2007). Development contexts and sporting success: birth date and birthplace effects in national hockey league draftees 2000-2005. *British Journal* of *Sports Medicine*, *41*(8), 515-517.

Baker, J., Schorer, J., Cobley, S., Schimmer, G., & Wattie, N. (2009). Circumstantial development and athletic excellence: The role of date of birth and birthplace. *European Journal of Sport Science*, *9*(6), 329-339.

Baldari, C., Di Luigi, L., Emerenziani, G.P., Gallota, M.C., Sgró, P., & Guidetti, L. (2009). Is explosive performance influenced by androgen concentrations in young male soccer players? *British Journal of Sports Medicine*, *43*, 191-194. doi: 10.1136/bjsm.2007.040386

Bangsbo, J. (1994). The physiology of soccer--with special reference to intense intermittent exercise. *Acta Physiologica Scandinavica Supplementum*, *619*, 1-155.

Bangsbo, J., Iaia, F.M., & Krustrup, P. (2008). The Yo-Yo intermittent recovery test: a useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine, 38*(1), 37-51.

Bangsbo, J., & Krustrup, P. (2009). Physical demands and training of top-class soccer players. In T. Reilly & F. Korkusuz (Eds.), *Science and Football VI*, (pp. 318-330). London: Routledge.

Bangsbo, J., & Michalsik, L. (2002). Assessment and physiological capacity of elite soccer players. In W. Spinks, T. Reilly, & Murphy, A. (Eds.), *Science and Football IV* (pp. 53-62). London: Routledge.

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sport Sciences*, *24*(7), 665-674.

Bansgbo, J., Nørregaard, L., & Thorsø, M. (1991). Activity profile of competition soccer. *Canadian Journal of Sport Science, 16*(2), 110-116.

Barnsley, R.H., & Thomson, A.H. (1988). Birthdate and success in minor hockey: The key to the N.H.L. Canadian. *Journal of Behavioral Science*, *20*, 167-176.

Barnsley, R.H., Thompson, A.H., & Barnsley, P.E. (1985). Hockey success and birth-date: The relative age effect. *Journal of the Canadian Association for Health, Physical Education, and Recreation*, *51*, 23-28.

Barnsley, R.H., Thompson, A.H., & Legault, P. (1992). Family planning: Football style, the relative age effect in football. *International Review for the Sociology of Sport, 27*, 77-88.

Barrow, H. M. (1954). Test of Motor Ability for College Men. *Research Quaterly*, *25*(3), 253-260.

Baxter-Jones, A.D.G., Eisenmann, J.C., & Sherar, L.B. (2005). Controlling for biological maturity in pediatric exercise science. *Pediatric Exercise Science*, *17*, 18-30.

Baxter-Jones, A., Goldstein, H., & Helms, P. (1993). The development of aerobic power in young athletes. *Journal of Applied Physiology*, *75*(3), 1160-1167.

Baxter-Jones, A.D., Helms, P., Mafulli, N., Baines-Preece, J.C., & Preece, M. (1995). Growth and development of male gymnasts, swimmers, soccer and tennis players: a longitudinal study. *Annals of Human Biology*, *22*(5), 381-394.

Beneke, R., Hütler, M., & Leithäuser, R.M. (2007). Anaerobic performance and metabolism in boys and male adolescents. *European Journal of Applied Physiology*, *101*(6), 671-677.

Beunen, G., Baxter-Jones, A.D., Mirwald, R.L., Thomis, M., Lefevre, J., Malina, R.M., & Bailey D.A. (2002). Intraindividual allometric development of aerobic power in 8- to 16-year-old boys. *Medicine & Science in Sports & Exercise*, *34*(3), 503-510.

Beunen, G., & Malina, R.M. (1988). Growth and physical performance relative to the timing of the adolescent spurt. *Exercise and Sport Sciences Reviews*, *16*, 503-540.

Beunen, G., & Malina, R.M. (Eds.). (2007). *Growth and Biologic Maturation: Relevance to Athletic Performance.* Capetown: Karger.

Beunen, G.P., Malina, R.M., Renson, R., Simons, J., Ostyn, M., & Lefevre, J. (1992). Physical activity and growth, maturation and performance: a longitudinal study. *Medicine & Science in Sports & Exercise*, *24*(5), 576-585.

Beunen, G., Ostyn, M., Simons, J., Renson, R., Claessens, A., Van den Eynde, B., … van`t Hof, M.A. (1997). Development and tracking in fitness components: Leuven longitudinal study on lifestyle, fitness and health. *International Journal of Sports Medicine*, *18*(3), 171-178.

Beunen, G., Ostyn, M., Simons, R., Renson, R., & Van Gerven, D. (1981). Chronological and biological age as related to physical fitness in boys 12 to 19 years. *Annals of Human Biology*, *8*(4), 321-331.

Binello, E., & Gordon, C.M. (2003). Clinical uses and misuses of dehydroepiandrosterone. *Current Opinion in Pharmacology*, *3*(6), 635-641.

Bloomfield, J., Polman, R., Butterly, R., & O'Donoghue, P. (2005). Analysis of age, stature, body mass, BMI and quality of elite soccer players from 4 European leagues. *The Journal of Sports Medicine and Physical Fitness*, *45*(1), 58-67.

Bosco, C. (Ed.). (1994). *Propuesta de valoración de las capacidades fisiológicas y neuromusculares del futbolista*. Barcelona: Paidotribo.

Bouchard, C., Malina, R.M., Hollmann, W., & Leblanc, C. (1976). Relationships between skeletal maturity and submaximal working capacity in boys 8 to 18 years. *Medicine & Science in Sports & Exercise*, *8*(3), 186-190.

Burdukiewicz, A., Chmura, J., Pietraszewska, J., Andrzejewska, J., Stachoń, A., & Nosal, J. (2013). Characteristics of body tissue composition and functional traits in junior football players. *Human Movement*, *14*(2), 96–101.

Butterfield, S.A., Lehnhard, R., Lee, J., & Coladarci, T. (2004). Growth rates in running speed and vertical jumping by boys and girls ages 11-13. Perceptual Motor Skills., 99(1), 225-34.

Butterfield, S.A., Lehnhard, R.A., Loovis, E.M., Coladarci, T., & Saucier, D. (2009). Grip strength performances by 5- to 19-year-olds. *Perceptual Motor Skills*, *109*(2), 362-370.

Buttifant, D., Graham, K., & Cross, K. (2002). Agility and speed in soccer players are two different performance parameters. In W. Spinks, T. Reilly, & A. Murphy (Eds.), *Science and football IV* (pp. 329-332). London: Routledge.

Cadore, E., Lhullier, F., Brentano, M., Silva, E., Ambrosini, M., Spinelli, R., … Kruel, L. (2008). Correlations between serum and salivary hormonal concentrations in response to resistance exercise. *Journal of Sports Sciences*, *26*(10), 1067-1072. doi: 10.1080/02640410801919526

Caldwell, B.P., & Peters, D.M. (2009). Seasonal variation in physiological fitness of a semiprofessional soccer team. *Journal of Strength and Conditioning Research*, *23*(5), 1370-1377. doi: 10.1519/JSC.0b013e3181a4e82f

Canhadas, I., Silva, R.P., Chaves, C.R., & Portes, L.A. (2010). Anthropometric and physical fitness characteristics of young male soccer players. *Brazilian Journal of Kinanthropometry and Human Performance*, *12*(4), 239-245.

Carling, C., Le Gall, F., Reilly, T., & Williams, AM. (2009). Do anthropometric and fitness characteristics vary according to birth date distribution in elite youth academy soccer players? *Scandinavian Journal of Medical Science and Sports*, *19*, 3-9. doi: 10.1111/j.1600-0838.2008.00867

Carvalho, H.M. (2011). Short-term maximal effort and isokinetic strength in youth basketball: scaling the effects of age, maturation and body size. (Doctoral dissertation, University of Coimbra, Faculty of Sport Sciences and Physical Education, Coimbra, Portugal).

Carvalho, H.M., Milano, G.E., Lopes, W.A., Figueiredo, A.J., Radominski, R.B., & Leite, N. (2013). Peak oxygen uptake responses to training in obese adolescents: a multilevel allometric framework to partition the influence of body size and maturity status. *BioMed Research International*, 8(Article ID 618595). doi: 10.1155/2013/618595

Carvalho, H.M., Silva, M.J., Figueiredo, A.J., Gonçalves, C.E., Philippaerts, R.M., Castagna, C., & Malina, R.M. (2011). Predictors of maximal short-term power outputs in basketball players 14-16 years. *European Journal of Applied Physiology*, *111*(5), 789-796. doi: 10.1007/s00421-010-1703-4

Casajús, J.A., & Aragonés, M.T. (1997). Estudio cineantropométrico del futbolista profesional español. *Archivos Médicos Deportivos*, *59*, 177-184.

Castagna, C., Impellizzeri, F.M., Belardinelli, R., Abt, G., Coutts, A., Chamari, K., & D´Ottavio, S. (2006). Cardiorespiratory responses to Yo-yo Intermittent Endurance Test in nonelite youth soccer players. *Journal of Strength and Conditioning Research*, *20*(2), 326-330.

Castagna, C., Impellizzeri, F., Cecchini, E., Rampinini, E., & Alvarez, J.C. (2009). Effects of intermittent-endurance fitness on match performance in young male soccer players. *Journal of Strength and Conditioning Research*, *23*(7), 1954-1959. doi: 10.1519/JSC.0b013e3181b7f743

Chamari, K., Chaouachi, A., Hambli, M., Kaouech, F., Wisløff, U., & Castagna, C. (2008). The five-jump test for distance as a field test to assess lower limb explosive power in soccer players. *Journal of Strength and Conditioning Research*, *22*(3), 944-950. doi: 10.1519/JSC.0b013e31816a57c6

Chamari, K., Hachana, Y., Ahmed, Y.B., Galy, O., Sghaïer, F., Chatard, J.C., Hue, O., & Wisløff, U. (2004). Field and laboratory testing in young elite soccer players. *British Journal of Sports Medicine*, *38*, 191-196. doi:10.1136/bjsm.2002.004374

Cobley, S., Baker, J., Wattie, N., & McKenna, J. (2009). Annual age-grouping and athlete development. A meta-analytical review of relative age effects in sport. *Sports Medicine, 39*(3), 235-256. doi: 10.2165/00007256-200939030-00005

Cohen, J. (Ed.). (1988). *Statistical power analysis for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Lawrence Earlbaum Associates.

Cohen, D.D., Voss, C., Taylor, M.J., Stasinopoulos, D.M., Delextrat, A., & Sandercock, G.R. (2010). Handgrip strength in English schoolchildren. *Acta Paediatrica*, *99*(7), 1065-1072. doi: 10.1111/j.1651-2227.2010.01723

Cometti, G., Maffiuletti, N.A., Pousson, M., Chatard, J.C., & Maffulli, N. (2001). Isokinetic strength and anaerobic power of elite, subelite and amateur soccer players. *International Journal of Sport Medicine*, *22*(1), 45-51.

Corrigan, B. (1999). DHEA and sport. *Clinical Journal of Sports Medicine, 12*(4), 206-241.

Coyle, E.F., Martin, W.H., Sinacore, D.R., Joyner, M.J., Hagberg, J.M., & Holloszy, J.O.(1984). Time course of loss of adaptations after stopping prolonged intense endurance training. *Journal of Applied Physiology Respiratory Environmental and Exercise Physiology, 57*(6), 1857-1864.

Dabbs, J.M. (1990a). Salivary testosterone measurements: collecting, storing, and mailing saliva samples. *Physiology & Behaviour*, *49*(4), 815-817.

Dabbs, J.M. (1990b). Salivary testosterone measurements: reliability across hours, days and weeks. *Physiology & Behaviour*, *48*(1), 83-86.

Dawson, B., Goodman, C., Lawrence, S., Preen, D., Polglaze, T., Fitzsimons, M., & Fournier, P. (1997). Muscle phosphocreatine repletion following single and repeated short sprint efforts. *Scandinavian Journal of Medicine and Science in Sports*, *7*(4), 206-213.

Delorme, N., Boiche, J., & Raspaud, M. (2010). Relative age and dropout in French male soccer. *Journal of Sports Sciences*, *28*(7), 717-722. doi: 10.1080/02640411003663276

Deprez, D., Coutts, A.J., Fransen, J., Deconinck, F., Lenoir, M., Vaeyens, R., & Philippaerts, R. (2013). Relative age, biological maturation and anaerobic characteristics in elite youth soccer players. *International Journal of Sports Medicine*, *34*(10), 897-903. doi: 10.1055/s-0032-1333262

Deprez, D., Vaeyens, R., Coutts, A.J., Lenoir, M., & Philippaerts, R. (2012). Relative age effect and Yo-Yo IR1 in youth soccer. *International Journal of Sports Medicine*, *33*(12), 987-993. doi: 10.1055/s-0032-1311654

Di Luigi, L., Baldari, C., Gallotta, M.C., Perroni, F., Romanelli, F., Lenzi, A., & Guidetti, L. (2006). Salivary steroids at rest and after a training load in young male athletes: relationship with chronological age and pubertal development. *International Journal of Sports Medicine*, *27*(9), 709-717.

Drust, B., Reilly, T., & Rienzi, E. (1998). Analysis of work rate in soccer. *Sports Exercise and Injury*, *4*, 151-155.

Dudink, A. (1994). Birth date and sporting success. *Nature, 368*, 592.

Durdiaková, J., Fábryová, H., Koborová, I., Ostatníková, D., & Celec, P. (2013). The effects of saliva collection, handling and storage on salivary testosterone measurement. *Steroids, 78*(14), 1325-1331. doi: 10.1016/j.steroids.2013.09.002

Ekblom, B. (1986). Applied physiology of soccer. *Sports Medicine*, *3*(1), 56-61.

Ekblom, B. (Ed.). (1999). *Manual de Ciencias del entrenamiento*. Barcelona: Paidotribo.

Eloranta, V. (2003). Influence of sports background on leg muscle coordination in vertical jumps. *Electroencephalography and Clinical Neurophysiology, 43*(3), 414-156.

Evans, J. D. (Ed.). (1996). *Straightforward statistics for the behavioral sciences*. Pacific Grove, CA: Brooks/Cole Publishing

Fairclough, S.J., & Ridgers, N. (2010). Relationship between maturity status, physical activity, and physical self-perceptions in primary school children. *Journal of Sports Sciences, 28*(1), 1-9. doi: 10.1080/02640410903334780

Faulkner, J.A. (1968). Physiology of swimming and diving. In H. Falls (Ed.), *Exercise Physiology* (pp. 415-445). Baltimore: Academic Press.

Fedor, A. & Gunstad, J. (2013). Higher BMI is associated with reduced cognitive performance in division I athletes. *Obesity Facts, 6*(2), 185-192. doi: 10.1159/000351138.

Feliú Rovira, A., Albanell Pemán, M., Bestit Cartasona, C., Baños Martínez, F., Fernández-Ballart, J., & Marti-Henneberg, C. (1991). Prediction of physical endurance in athletes during puberty: analysis of high performance soccer players. *Anales de Pediatría. Asociación española de pediatría*, *35*(5), 323-326.

Ferrete, C., Requena, B., Suarez-Arrones, L., & Sáez de Villarreal, E. (2014). Effect of strength and high-intensity training on jumping, sprinting and intermitent endurance performance in prepubertal soccer players. *Journal of Strength and Conditioning Research, 28*(2), 413-422. doi: 10.1519/JSC.0b013e31829b2222

Figueiredo, A.J., Coelho e Silva, M.J., & Malina, R.M. (2011). Predictors of functional capacity and skill in youth soccer players. *Scandinavian Journal of Medicine & Science in Sports, 21*(3), 446-454. doi: 10.1111/j.1600-0838.2009.01056

Figueiredo, A.J., Goncalves, C.E., Coelho E Silva M.J., & Malina, R.M. (2009). Characteristics of youth soccer players who drop out, persist or move up. *Journal of Sports Science*, *27*(9), 883-891.

Fredriks, A.M., van Buuren, S., Fekkes, M., Verloove-Vanhorick, S.P., & Wit, J.M. (2005). Are age references for waist circumference, hip circumference and waist-hip ratio in Dutch children useful in clinical practice? *European Journal of Pediatrics*, *164*(4), 216-222.

Geithner, C.A., Satake, T., Woynarowska, B., & Malina, R.M. (1999). Adolescent spurts in body dimensions: Average and modal sequences. *American Journal of Human Biology*, *11*(3), 287-295.

Geithner, C.A., Thomis, M.A., Eynde, B.V., Maes, H.H.M., Loos, R.J.F., Peeters, M., … Beunen, G.P. (2004). Growth in Peak Aerobic Power during Adolescence. *Medicine & Science in Sports & Exercise*, *36*(9), 1616-1624.

Gil, S.M. (2003). *Garapenean dauden futbolarien ezaugarri antropometriko eta fisiologikoak*. (Doctoral dissertation, University of the Basque Country, Department of Physiology, Faculty of Medicine and Dentistry, Basque Coutry).

Gil, S.M., Badiola, A., Bidaurrazaga-Letona, I., Zabala-Lili, J., Gravina, L., Santos-Concejero, J., … Granados, C. (2014). Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *Journal of Sports Sciences, 32*(5), 479-486. doi: 10.1080/02640414.2013.832355

Gil, S.M., Gil, J., Ruiz, F., Irazusta, A., & Irazusta, J. (2007). Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. *Journal of Strength Conditioning Research, 21*(2), 438-445.

Gil, S.M., Gil, J., Ruiz, F., Irazusta, A., & Irazusta, J. (2010). Anthropometrical characteristics and somatotype of young soccer players and their comparison with the general population. *Biology of Sport*, *27*(1), 17-24.

Gil, S., Ruiz, F., Irazusta, A., Gil, J., & Irazusta J. (2007). Selection of young soccer players in terms of anthropometric and physiological factors. *Journal of Sports Medicine and Physical Fitness*, *47*(1), 25-32.

Gilsanz, V., & Ratib, O. (Eds.). (2005). *Hand bone Age. A digital atlas of skeletal maturity*. Berlin: Springer.

González, J.J., & Villegas, J.A. (Eds.). (1999). *Valoración del deportista. Aspectos biomédicos y funcionales*. Pamplona: Femede.

Gore, C., Norton, K., & Olds, T. (2000). Acreditación en antropometría: un modelo australiano. In K. Norton & T. Olds (Eds.), *Antropométrica* (pp. 263-272). Argentina: Biosystem Servicio Educativo.

Granger, D., Cicchetti, D., Rogosch, F., Hibel, L., Teisl, M., & Flores, E. (2007). Blood contamination in children´s saliva: prevalence, stability, and impact on the measurement of salivary cortisol, testosterone and dehydroepiandrosterone. *Psychoneuroendocrinology*, *32*(6), 724-733.

Granger, D.A., Schwartz, E.B., Booth, A., & Arentz, M. (1999). Salivary testosterone determination in studies of child health and development. *Hormones & Behaviour*, *35*(1), 18-27.

Granger, D.A., Schwartz, E.B., Booth, A., Curran, M., & Zakaria, D. (1999). Assesing dehydroepiandosterone in saliva: a simple radioimmunoassay for use in studies of children, adolescents and adults. *Psiconeuroendocrinology*, *24*(5), 567-579.

Granger, D.A., Shirtcliff, E.A., Booth, A., Kivlighan, K.T., & Schwartz, E.B. (2004). The "trouble" with salivary testosterone. *Psychoneuroendocrinology*, *29*(10), 1229-1240.

Gravina, L., Gil, S.M., Ruiz, F., Zubero, J., Gil, J., & Irazusta, J. (2008). Anthropometric and physiological differences between first team and reserve soccer players aged 10-14 years at the beginning and end of the season. *Journal of Strength and Conditioning Research*, *22*(4), 1308-1314. doi: 10.1519/JSC.0b013e31816a5c8e

Häger-Ross, C., & Rösblad, B. (2002). Norms for grip strength in children aged 4-16 years. *Acta Paediatrica*, *91*(6), 617-625.

Hansen, L., Bangsbo, J., Twisk, J., & Klausen, K. (1999). Development of muscle strength in relation to training level and testosterone in young male soccer players. *Journal of Applied Physiology, 87*(3), 1141-1147.

Hammami, M.A., Ben Abderrahmane, A., Nebigh, A., Le Moal, E., Ben Ounis, O., Tabka, Z., & Zouhal, H. (2013). Effects of a soccer season on anthropometric characteristics and physical fitness in elite young soccer players. *Journal of Sports Sciences*, *31*(6), 589-596. doi: 10.1080/02640414.2012.746721

Hashemi-Nejad, N., Choobineh, A., Reza Baneshi, M., & Roodbandi, A.J. (2013). Intra-observer and Inter-observer Reliabilty in Direct Anthropometry. *International Journal of occupational hygiene*, *5*(2), 82-88.

Havelock, J.C., Auchus, R.J., & Rainey, W.E. (2004). The rise in adrenal androgen biosynthesis: adrenarche. *Seminars in reproductive medicine*, *22*(4), 337-347.

Heath, B.H., & Carter, J.E. (1967). A modified somatotype method. *American Journal of Physical Anthropology, 27*(1), 57-74.

Helsen, W.F., Hodges, N.J., Van Winckel, J.A., & Starkes, J.L. (2000). The roles of talent, physical precocity and practice in the development of soccer expertise. *Journal of Sports Science*, *18*(9), 727-736.

Helsen, W.F., Starkes, J.L., & Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *American Journal of Human Biology*, *10*(6), 791-798.

Helsen, W.F., Starkes, J.L., & Van Winckel, J. (2000). Effect of a change in selection year on success in male soccer players. *American Journal of Human Biology*, *12*(6), 729-735.

Helsen, W.F., Van Winckel, J.A., & Williams, M. (2005). The relative age effect in youth soccer across Europe. *Journal of sport sciences*, *23*(6), 629-636.

Hernández, M., Castellet, J., Narvaíza, J. L., Rincón, J. M., Ruiz, I., & Sánchez, E. (Eds.). (1988). *Curvas y tablas de crecimiento*. Madrid: Garsi.

Hoff, J., & Helgerud, J. (2004). Endurance and strength training for soccer players: physiological considerations. *Sports Medicine*, *34*(3), 165-180.

Huijgen, B.C., Elferink-Gemser, M.T., Post, W.J., & Visscher, C. (2009). Soccer skill development in professionals. *International Journal of Sports Medicine*, *30*(8), 585-591. doi: 10.1055/s-0029-1202354

Huijgen, B.C., Elferink-Gemser, M.T., Post, W., & Visscher, C. (2010). Development of dribbling in talented youth soccer players aged 12-19 years: a longitudinal study. *Journal of Sports Sciences*, *28*(7), 689-698. doi: 10.1080/02640411003645679

Jastrzębski, Z., Rompa, P., Szutowicz, M., & Radzimiński, L. (2013). Effects of applied training loads on the aerobic capacity of young soccer players during a soccer season. *Journal of Strength and Conditioning Research, 27*(4), 916-23. doi: 10.1519/JSC.0b013e31825c327a

Jiménez, I.P., & Pain, M.T. (2008). Relative age effect in Spanish association football: Its extent and implications for wasted potential*. Journal of Sport Science, 26*(10), 995-1003. doi: 10.1080/02640410801910285

Jones, M.A., Hitchen, P.J., & Stratton, G. (2000). The importance of considering biological maturity when assessing physical fitness measures in girls and boys aged 10 to 16 years. *Annals of Human Biology*, *27*(1), 57-65.

Júdice, P.B., Silva, A.M., Magalhães, J.P., Matias, C.N., & Sardinha, L.B.(2014).Sedentary behaviour and adiposity in elite athletes. *Journal of Sports Sciences, 32*(19), 1760-1767. doi: 10.1080/02640414.2014.926382.

Juricskay, Z., & Mezey, B. (1994). Effect of regular training on the anthropometric parameters and urine steroids in childhood. *European Journal of Applied Physiology*, *68*(4), 367-372.

Keizer, H., Janssen, G.M., Menheere, P., & Kranenburg, G. (1989). Changes in basal plasma testosterone, cortisol, and dehydroepiandrosterone sulfate in previously untrained males and females preparing for a marathon. *International Journal of Sports Medicine*, *10*(3), 139-145.

Kirkendall, D.T., & Street, G.M. (1986). Mechanical jumping power in athletes. *British Journal of Sports Medicine, 20*(4), 163-164.

Koundourakis NE, Androulakis NE, Malliaraki N, Tsatsanis C, Venihaki M, et al. (2014) Discrepancy between Exercise Performance, Body Composition, and Sex Steroid Response after a Six-Week Detraining Period in Professional Soccer Players. *PLoS ON, 9*(2): e87803. doi:10.1371/journal.pone.0087803

Kroboth, P.D., Salek, F.S., Pittenger, A.L., Fabian, T.J., & Frye, R.F. (1999). DHEA and DHEA-S: a review. *The journal of clinical pharmacology*, *39*(4), 327-348.

Krustrup, P., Christensen, J.F., Randers, M.B., Pedersen, H., Sundstrup, E., Jakobsen, M.D., … Bangsbo, J. (2010). Muscle adaptations and performance enhancements of soccer training for untrained men. *European Journal of Applied Physiology*, *108*(6), 1247-1258. doi: 10.1007/s00421-009-1319-8

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., … Bangsbo, J. (2003). The Yo-Yo Intermittent Recovery Test: Physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise*, *35*(4), 697-705.

Krustrup, P., Mohr, M., Nybo, L., Jensen, J.M., Nielsen, J.J., & Bangsbo, J. (2006). The Yo-Yo IR2 test: physiological response, reliability, and application to elite soccer. *Medicine & Science in Sports & Exercise*, *38*(9), 1666-1673.

Lago-Peñas, C., Rey, E., Casáis, L., & Gómez-López, M. (2014). Relationship between performance characteristics and the selection process in youth soccer players. *Journal of Human Kinetics*, *40*, 189-199. doi: 10.2478/hukin-2014-0021

Le Gall, F., Carling, C., & Reilly, T. (2007). Biological maturity and injury in elite youth football. *Scandinavian Journal of Medicine & Sciences in Sports, 17*(5), 564-572.

Le Gall, F., Carling,C., Williams, M., & Reilly, T. (2010). Anthropometric and fitness characteristics of international, professional and amateur male graduate soccer players from an elite youth academy. *Journal of Science and Medicine in Sport, 13*(1), 90-95. doi: 10.1016/j.jsams.2008.07.004

Littlewood, M., Richardson, D., Gilbourne, D., & Atkinson, G. (2005). Relative age effect amongst 2811 professional footballers playing in England between 1990 and 2000. In N. Dikic, S. Zivanic, S. Ostojic, Z. Tornjanski (Eds.), *European College of Sports Science (ECSS), 10th Annual Congress*. Belgrade, Serbia.

Lloyd, R.S., Oliver, J.L., Radnor, J.M., Rhodes, B.C., Faigenbaum, A.D., & Myer, G.D. (2014). Relationships between functional movement screen scores, maturation and physical performance in young soccer players. *Journal of Sports Sciences*, *23*, 1-9.

Malina, R.M. (1994). Physical activity and training: effects on stature and the adolescent growth spurt. *Medicine and Science in Sports and Exercise*, *26*(6), 759-766.

Malina, R.M. (2011). Skeletal age and age verification in youth sport. *Sports Medicine, 41*(11), 925-947. doi: 10.2165/11590300-000000000-00000

Malina, R.M. (2014). Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Research Quaterly for Exercise and Sport*, *85*(2), 157-173.

Malina, R.M., & Bouchard, C. (Eds.). (1991). *Growth, maturation and physical activity*. United States: Human Kinetics, Champaign.

Malina, R.M., Bouchard, C., & Bar-Or, O. (Eds.) (2004). *Growth, maturation and physical activity*. Leeds: Human Kinetics.

Malina, M., Chamorro, M., Serratosa, L., & Morate, F. (2007). TW3 and Fels skeletal ages in elite youth players. *Annals of Human Biology*, *34*(2), 265-272.

Malina, R.M., Cumming, S.P., Kontos, A.P., Eisenmann, J.C., Ribeiro, B., & Aroso, J. (2005). Maturity-associated variation in sport-specific skills of youth soccer players aged 13-15 years. *Journal of Sports Science*, *23*(5), 515-522.

Malina, R.M., Cumming, S.P., Morano, P.J., Barron, M., & Miller, S.J. (2005). Maturity status of youth football players: a noninvasive estimate. *Medicine and Science in Sports and Exercise*, *37*(6), 1044-1052.

Malina, R.M., Eisennman, J.C., Cumming, S.P., Ribeiro, B., & Aroso, J. (2004). Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. *European Journal of Applied Physiology*, *91*(5-6), 555-562.

Malina, R.M., & Kozieł, S.M. (2014). Validation of maturity offset in a longitudinal sample of Polish boys. *Journal of Sports Sciences*, *32*(5), 424-437. doi: 10.1080/02640414.2013.828850

Malina, R.M., Peña Reyes, M.E., Eisenmann, J.C., Horta, L., Rodrigues, J., & Miller, R. (2000). Height, mass and skeletal maturity of elite Portuguese soccer players aged 11-16 years. *Journal of Sports Science, 18*(9), 685-693.

Malina, R.M., Ribeiro, B., Aroso, J., & Cumming, S.P. (2007). Characteristics of youth soccer players aged 13-15 years classified by skill level. *British Journal of Sports Medicine*, *41*(5), 290-295. doi: 10.1136/bjsm.2006.031294

Malina, R., Rożek, K., Zofia Ignasiak, Z., Sławińska, T., Fugiel, J., Kochan, K., & Domaradzki, J. (2011). Growth and Functional Characteristics of Male Athletes 11-15 Years of Age. *Human movement*, *12*(2), 180-187. doi. 10.2478/v10038-011-0017-7

Malina, R.M., Woynarowska, B., Bielicki, T., Beunen, G., Eweld, D., Geithner, C.A., ... Rogers, D.M. (1997). Prospective and retrospective longitudinal studies of the growth, maturation, and fitness of Polish youth active in sport. *International Journal of Sports Medicine*, *18*(3), 179-185.

Markovic, G., & Mikulic, P. (2011). Discriminative ability of the Yo-Yo intermittent recovery test (level 1) in prospective young soccer players. *Journal of Strength and Conditioning Research*, *25*(10), 2931-2934. doi: 10.1519/JSC.0b013e318207ed8c

Matiegka, J. (1921). The testing of physical efficiency. *American Journal of Physical Anthropology*, *4*(3), 223-230. doi: 10.1002/ajpa.1330040302

Matthys, S.P., Vaeyens, R., Coelho-E-Silva, M.J., Lenoir, M., & Philippaerts, R. (2012). The contribution of growth and maturation in the functional capacity and skill performance of male adolescent handball players. *International Journal of Sports Medicine, 33*(7), 543-549. doi: 10.1055/s-0031-1298000

McMillan, K., Helgerud, J., Macdonald, R., & Hoff, J. (2005). Physiological adaptations to soccer specific endurance training in professional youth soccer players. *British Journal of Sports Medicin*e, *39*(5), 273-277.

Melchiorri, G., Ronconi, M., Triossi, T., Viero, V., De Sanctis, D., Tancredi, V.,... & Alvero Cruz, J.R. (2014). Detraining in young soccer players. *Journal Sports Medicine and Physical Fitness*, *54*(1), 27-33.

Meylan, C., Cronin, J., Oliver, J., & Hughes, M. (2010). Talent Identification in Soccer: The Role of Maturity Status on Physical, Physiological and Technical Characteristics. *International Journal of Sports Science & Coaching, 5*(4), 571-591.

Michailidis, Y., Fatouros, I.G., Primpa, E., Michailidis, C., Avloniti, A., Chatzinikolaou, A., ... Kambas, A. (2013). Plyometrics' trainability in preadolescent soccer athletes. *Journal of Strength and Conditioning Research*, *27*(1), 38-49. doi: 10.1519/JSC.0b013e3182541ec6

Miller, T.A., Thierry-Aguilera, R., Congleton, J.J., Amendola, A.A., Clark, M.J., Crouse, S.F., … Jenkins, O.C. (2007). Seasonal changes in VO2max among Division 1A collegiate women soccer players. *Journal of Strength and Conditioning Research*, *21*(1), 48-51.

Mirkov, D.M., Kukolj, M., Ugarkovic, D., Koprivica, V.J., & Jaric, S. (2010). Development of anthropometric and physical performance profiles of young elite male soccer players: a longitudinal study. *Journal of Strength and Conditioning Research*, *24*(10), 2677-2682. doi: 10.1519/JSC.0b013e3181e27245

Mirkov, D.M, Nedeljkovic, A., Milanovic, S., & Jaric, S. (2004). Muscle strength testing: evaluation of tests of explosive force production. *European Journal Applied Physiology*, *91*(2-3), 147-154.

Mirwald, R.L., Baxter-Jones, A.D., Bailey, D.A., & Beunen, G.P. (2002). An assessment of maturity from anthropometric measurements. *Medicine & Science in Sports & Exercise*, *34*(4), 689-694.

Mohr, M., Krustrup, P., & Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences*, *21*(7), 519-528.

Moreira, A., Mortatti, A., Aoki, M., Arruda, A., Freitas, C., & Carling, C. (2013). Role of Free Testosterone in Interpreting Physical Performance in Elite Young Brazilian Soccer Players. *Pediatric Exercise Science*, *25*(2), 186-197.

Morris, T. (2000). Psychological characteristics and talent identification in soccer. *Journal of Sports Science, 18*(9), 715-726.

Mujika, I., & Padilla, S. (2000). Detraining: loss of training-induced physiological and performance adaptations. Part I. Short term insufficient training stimulus. *Sports Medicine, 30,* 145-154.

Mujika, I., & Padilla, S. (2001). Cardiorespiratory and metabolic characteristics of detraining in humans. *Medicine & Science in Sports & Exercise, 33*(3):413-421.

Mujika, I., Santisteban, J., Impellizzeri, F.M., & Castagna, C. (2009). Fitness determinants of success in men's and women's football. *Journal of Sports Science, 27*(2), 107-114. doi: 10.1080/02640410802428071

Mujika, I., Spencer, M., Santisteban, J., Goiriena, J.J., & Bishop, D. (2009). Age-related differences in repeated-sprint ability in highly trained youth football players. *Journal of Sports Sciences*, *27*(14), 1581-1590. doi: 10.1080/02640410903350281

Mujika, I., Vaeyens, R., Matthys, S.P.J., Santiesteban, J., Goiriena, J., & Philippaerts, R. (2009).The relative age effect in a professional football club setting. *Journal of Sports Science, 27*(11), 1153-1158. doi: 10.1080/02640410903220328

Musch, J., & Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Developmental Review, 21*, 147-167. doi:10.1006/drev.2000.0516

Musch, J., & Hay, R. (1999). The Relative Age Effect in soccer: cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Sociology of Sport Journal*, *16*, 54-56.

Netherton, C., Goodyer, I., Tamplin, A., & Herbert, J. (2004). Salivary cortisol and dehydroepiandrosterone in relation to puberty and gender. *Psychoneuroendocrinology, 29*(2), 125-140.

Nevill, A.M., Holder, R.L., Baxter-Jones, A., Round, J.M., & Jones, D.A. (1998). Modeling developmental changes in strength and aerobic power in children. *Journal of Applied Physiology*, *84*(3), 963-970.

Nevill, A., Holder, R., & Watts, A. (2009). The changing shape of “successful” professional footballers. *Journal of Sports Sciences, 27*(5), 419-426. doi: 10.1080/02640410802668676

Nikolaidis, P.T. (2012a). Elevated Body Mass Index and Body Fat Percentage Are Associated with Decreased Physical Fitness in Soccer Players Aged 14–16 Years. *Asian Journal of Sports Medicine*, *3*(3), 168–174.

Nikolaidis, P.T. (2012b). Physical fitness is inversely related with body mass index and body fat percentage in soccer players aged 16-18 years. *Medicinski pregled*, *65*(11-12), 470-475.

Nikolaidis, P. (2014) Age-related Differences in Countermovement Vertical Jump in Soccer Players 8-31 Years Old: the Role of Fat-free Mass. *American Journal of Sports Science and Medicine*, *2*(2), 60-64. doi:10.12691/ajssm-2-2-1

Nikolaidis, P.T., & Vassilios Karydis, N. (2011). Physique and body composition in soccer players across adolescence. *Asian Journal of Sports Medicine*, *2*(2), 75-82.

Nikolaidis, P., Ziv, G., Lidor, R., & Arnon, M. (2014). Inter-individual Variability in Soccer Players of Different Age Groups Playing Different Positions. *Journal of Human Kinetics*, *40*, 213-225. doi: 10.2478/hukin-2014-0023

Ostatníková, D., Pastor, K., Putz, Z., Dohnányiová, M., Mat´aseje, A., & Hampl, R. (2002). Salivary testosterone levels in preadolescent children. *BMC Pediatrics*, *3*, 2-5. doi:10.1186/1471-2431-2-5

Papacosta, E., & Nassis, G. (2011). Saliva as a tool for monitoring steroid, peptide and immune markers in sport and exercise science. *Journal of Science and Medicine in Sport, 14*(5), 424-434. doi: 10.1016/j.jsams.2011.03.004

Pearson, D.T., Naughton, G.A., & Torode, M. (2006). Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. *Journal of Science and Medicine in Sport*, *9*(4), 277-287.

Peat, J., & Barton, B. (Eds.). (2005). *Medical statistics. A guide to data analysis and critical appraisal*. Australia: Blackwell Publishing.

Peña-Reyes, M.E., Cardenas-Barahona, E., & Malina, R.M. (1994). Growth, physique, and skeletal maturation of soccer players 7-17 years of age. *Humbiologia Budapestinensis, 25*, 453-458.

Perini, T.A., Oliveira, G.L., Ornellas, J.S., & Oliveira, F.P. (2005). Technical error of measurement in anthropometry. *Revista Brasileira de Medicina do Esporte*, *11*(1), 81–85.

Philippaerts, R.M., Vaeyens, R., Janssens, M., Van Renterghem, B., Matthys, D., Craen, R., … Malina, R.M. (2006). The relationship between peak height velocity and physical performance in youth soccer players. *Journal of Sports Science, 24*(3), 221-230.

Ploegmakers, J.J., Hepping, A.M., Geertzen, J.H., Bulstra, S.K., & Stevens, M. (2013). Grip strength is strongly associated with height, weight and gender in childhood: a cross sectional study of 2241 children and adolescents providing reference values. *Journal of Physiotherapy*, *59*(4), 255-261. doi: 10.1016/S1836-9553(13)70202-9

Rampinini, E., Sassi, A., Azzalin, A., Castagna, C., Menaspà, P., Carlomagno, D., & Impellizzeri, F.M. (2010). Physiological determinants of Yo-Yo intermittent recovery tests in male soccer players. *European Journal of Applied Physiology*, *108*(2), 401-409. doi: 10.1007/s00421-009-1221-4

Reilly, T., Bangsbo, J., & Franks, A. (2000). Anthropometric and physiological predispositions for elite soccer. *Journal of Sports Sciences*, *18*(9), 669-683.

Reilly, T., & Thomas, V. (1976). A motion analysis of work-rate in different positional roles in professional football match-play. *Journal of Human Movement Studies*, *2*, 87-97.

Reilly,T., & Thomas, V. (1977). Applications of multivariate analysis to the fitness assessment of soccer players. *British Journal of Sports Medicine, 11*(4), 183-184.

Reilly, T., Williams, A.M., Nevill, A., & Franks, A. (2000). A multidisciplinary approach to talent identification in soccer. *Journal of Sports Science*, *18*(9), 695-702.

Ricardo, D.R., & Araujo, C.G. (2002). Body mass index: a scientific evidence-based inquiry. *Archivos Brasileiros de Cardiologia*, *79*(1), 61-78.

Rico-Sanz, J. (1997). Evaluaciones de rendimiento en futbolistas/ Performance evaluations in soccer players. *Archivos de Medicina del Deporte*, *14*, 207-212.

Rico-Sanz, J. (1998). Body composition and nutritional assessments in soccer. *International Journal of Sport Nutrition*, *8*(2), 113-123.

Rienzi, E., Drust, B., Reilly, T., Carter, J.E., & Martin, A. (2000). Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *Journal of Sports Medicine and Physical Fitness, 40*(2), 162-169.

Rilling, J.K., Worthman, C.M., Campbell, B.C., Stallings, J.F., & Mbizva, M. (1996). Ratios of plasma and salivary testosterone throughout puberty: production versus bioavailability. *Steroids*, *61*(6), 374-378.

Rocha, M.S.L. (1974). Peso ósseo do brasileiro de ambos sexos de 17 a 25 años. *Arquivos de anatomía e antropología*, *1*(1), 445-451.

Rogol, A.D. (2002). Androgens and puberty. *Molecular and Celular Endocrinology*, *198*, 25-29.

Rogol, A.D., Clark, P., & Roemmich, J. (2000). Growth and pubertal development in children and adolescents: effects of diet and physical activity. *The American Journal of Clinical Nutrition, 72*(2), 521-528.

Rogol, A.D., Roemmich, J.N., & Clark, P.A. (2002). Growth at puberty. *Journal of Adolescent Health*, *31*(6), 192-200.

Rowland, T.W. (Ed.). (2005). *Children's Exercise Physiology (2nd ed)*. Champaign: Human Kinetics.

Schorer, J., Cobley, S., Büsch, D., Bräutigam, H., & Baker, J. (2008). Influences of competition level, gender, player nationality, career stage and playing on relative age effects. *Scandinavian Journal of Medicine and Science of Sports*, *19*(5), 720-730. doi: 10.1007/s00421-009-1221-4

Sedano, S., Matheu, A., Redondo, J.C., & Cuadrado, G. (2011). Effects of plyometric training on explosive strength, acceleration capacity and kicking speed in young elite soccer players. *Journal of Sports Medicine and Physical Fitness*, *51*(1), 50-58.

Shephard, R.J. (1999). Biology and medicine of soccer: an update. *Journal of Sports Sciences, 17*(10), 757-786.

Sheppard, J.M., & Young, W.B. (2006). Agility literature review: classifications, training and testing. *Journal of Sports Sciences, 24*(9), 919-932.

Sherar, L.B., Baxter-Jones, A.D.G., Faulkner, R.A., & Russell, K.W. (2007). Do physical maturity and birth date predict talent in male youth ice hockey players? *Journal of Sports Science*, *25*(8), 879-886.

Sherar, L.B., Mirwald, R.L., Baxter-Jones, A.D., & Thomis, M. (2005). Prediction of adult height using maturity-based cumulative height velocity curves. *Journal of Pediatrics, 147*(4), 508-514.

Stewart, A., Marfell-Jones, M., Olds, T., & de Ridder, H. (Eds.). (2011). *International standards for anthropometric assessment*. Lower Hutt, New Zealand: The International Society for the Advancement of Kinanthropometry.

Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of Soccer. An Update. *Sports* Medicine, 35(6), 501-536.

Stratton, G., Reilly, T., Williams, A.M., & Richardson, D. (Eds.) (2004). *Youth Soccer: From Science to Performance.* London: Taylor and Francis.

Stroyer, J., Hansen, L., & Klausen, K. (2004). Physiological profile and activity pattern of young soccer players during match play. *Medicine & Science in Sports & Exercise*, *36*(1), 168–174.

Svensson, M., & Drust, B. (2005). Testing soccer players. *Journal of Sport Sciences*, *23*(6), 601-618.

Tanner, J.M. (Ed.). (1962). *Growth and adolescence*. Oxford: Blacwell Scientific Publications.

Thomas, K., French, D., & Hayes, P.R. (2009). The effect of two plyometric training techniques on muscular power and agility in youth soccer players. *Journal of Strength and Conditioning Research*, *23*(1), 332-335. doi: 10.1519/JSC.0b013e318183a01a

Thomasson, R., Baillot, A., Jollin, L., Lecoq, A.M., Amiot, V., Lasne, F., & Collomp, K. (2010). Correlation between plasma and saliva adrenocortical hormones in response to submaximal exercise. *Journal of Physiological Sciences, 60*(6), 435-439. doi: 10.1007/s12576-010-0106

Thompson, A.H., Barnsley, R.H., & Stebelsky, G. (1991). "Born to play ball" The relative age effect and mayor league baseball. *Sociology of Sport Journal*, *8*(2), 146-151.

Till, K., Cobley, S., O'Hara, J., Chapman, C., & Cooke, C. (2010). Anthropometric, physiological and selection characteristics in high performance UK junior Rugby League players. *Talent Development and Excellence*, *2*(2), 193-207.

Tonson, A., Ratel, S., Le Fur, Y., Cozzone, P., & Bendahan, D. (2008). Effect of maturation on the relationship between muscle size and force production. *Medicine and Science in Sports and Exercise*, *40*(5), 918-925. doi: 10.1249/MSS.0b013e3181641bed

Torres-Unda, J., Zarrazquin, I., Gil, J., Ruiz, F., Irazusta, A., Kortajarena, M., … & Irazusta, J. (2013). Anthropometric, physiological and maturational characteristics in selected elite and non-elite male adolescent basketball players. *Journal of Sport Sciences*, 31(2):196-203. doi: 10.1080/02640414.2012.725133

Tumilty, D. (1993a). Physiological characteristics of elite soccer players. *Sports Medicine*, *16*(2), 80-96.

Tumilty, D. (1993b). The relationship between physiological characteristics of junior soccer players and performance in a game situation. In T. Reilly, J. Clarys, & A. Stibb (Eds.), *Science and Football II* (pp. 281-286). London: E & FN Spon.

Ulijaszek, S.J., & Kerr, D.A. (1999). Anthropometric measurement error and the assessment of nutritional status. *British Journal of Nutrition*, *82*(3), 165-177.

Vaeyens, R., Coutts, A., & Philippaerts, R.M. (2005). Evaluation of the "under-21 rule": do young adult soccer players benefit*? Journal of Sports Science*, *23*(10), 1003-1012.

Vaeyens, R., Lenoir, M., Williams, A.M., & Philippaerts, R.M. (2008). Talent identification and development programmes in sport: current models and future directions. *Sports Medicine*, *38*(9), 703-714.

Vaeyens, R., Malina, R.M., Janssens, M., Van Renterghem, B., Bourgois, J., Vrijens, J., & Philippaerts, R.M. (2006). A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. *British Journal of Sports Medicine*, *40*(11), 928-934. doi: 10.1136/bjsm.2006.029652

Vaeyens, R., Philippaerts, R.M., & Malina, R.M. (2005). The relative age effect in soccer: a match-related perspective. *Journal of Sports Science*, *23*(7), 747-756.

Valente-Dos-Santos, J., Coelho-E-Silva, M.J., Severino, V., Duarte, J., Martins, R.S., Figueiredo, A.J., … Malina, R.M. (2012). Longitudinal study of repeated sprint performance in youth soccer players of contrasting skeletal maturity status. *Journal of Sports Science and Medicine, 11*, 371-379.

Valente-dos-Santos, J., Coelho-e-Silva, M.J., Simões, F., Figueiredo, A.J., Leite, N., Elferink-Gemser, M.T., … Sherar, L. (2012). Modeling developmental changes in functional capacities and soccer-specific skills in male players aged 11-17 years. *Pediatric Exercise Science*, *24*(4), 603-621.

Vandendriessche, J.B., Vaeyens, R., Vandorpe, B., Lenoir, M., Lefevre, J., & Philippaerts, R.M. (2012). Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15-16 years). *Journal of Sports Sciences*, *13*(15), 1695-1703. doi: 10.1080/02640414.2011.652654

Vanderford, M.L., Meyers, M.C., Skelly, W.A., Stewart, C.C., & Hamilton, K.L. (2004). Physiological and sport-specific skill response of olympic youth soccer athletes. *Journal of Strength and Conditioning Research*, *18*(2), 334-342.

Vänttinen, T. (2013). *Growth-associated variation in body size, hormonal status, physical performance characterstics and perceptual-motor skills in Finnish young soccer players.* A two year follow-up study in the U11, U13 and U15 age groups. (Doctoral dissertation, University of Jyväskylä, Faculty of Sport and Health Sciences, Jyväskylä).

Vänttinen, T., Blomqvist, M., Luhtanen, P., & Häkkinen, K. (2010). Effects of age and soccer expertise on general tests of perceptual and motor performance among adolescent soccer players. *Perceptual & Motor Skills*, *110*(3), 675-692.

Vänttinen, T., Blomqvist, M., Nyman, K., & Häkkinen, K. (2011). Changes in body composition, hormonal status, and physical fitness in 11-, 13-, and 15-year-old Finnish regional youth soccer players during a two-year follow-up. *Journal of Strength and Conditioning Research*, *25*(12), 3342-3351. doi: 10.1519/JSC.0b013e318236d0c2

Vicente-Rodriguez, G., Ara, I., Perez-Gomez, J., Serrano-Sanchez, J.A., Dorado, C., & Calbet, J.A. (2004). High femoral bone mineral density accretion in prepubertal soccer players. *Medicine & Science in Sports & Exercise, 36*(10), 1789-1795.

Vincent, J., & Glamser, F. (2006). Gender differences in the relative age effect among US Olympic Development Program youth soccer players. *Journal of Sports Sciences, 24*(4), 405-413.

Viru, A., Loko, J., Harro, M., Volver, A., Laaneots, L., & Viru, M. (1999). Critical periods in development of performance capacity during childhood and adolescence. *European Journal of Physical Education*, *4*(1), 75-119.

Viru, A. Loko, J., Volver, A., Laaneots, L., Karlesom, K., & Viru, M. (1998). Age periods of accelerated improvements of muscle strength, power, speed and endurance in age interval 6-18 years. *Biology of Sport*, *15*(4), 211-227.

Wattie, N., Cobley, S., & Baker, J. (2008). Towards a unified understanding of relative age effects. *Journal of Sports Sciences*, *26*(13), 1403-1409. doi: 10.1080/02640410802233034

Wein, H. (Ed.). (2004). *Futbol a medida del niño. Vol. I Desarrollar la inteligencia del juego para jugadores hasta diez años*. Las Rozas: Gymnos.

Weise, M., Eisenhofer, G., & Merke, D.P. (2002). Pubertal and gender-related changes in the sympathoadrenal system in healthy children. *The Journal of Clinical Endocrinology & Metabolism, 87*(11), 5038-5043.

Whetzel, C.A., & Klein, L.C. (2010). Measuring DHEA-S in saliva: time of day differences and positive correlations between two different types of collection methods. *BMC Research notes, 3*, 204-209. doi: 10.1186/1756-0500-3-204

White, J.E., Emery, T.M., Kane, J.L., Groves, R., & Risman, A.B. (1988). Pre-season profiles of professional soccer players. In T. Reilly, A. Lees, K. Davids, & W.J. Murphy (Eds.), *Science and Football* (pp. 164-171). London: E & FN Spon.

Wilmore, J.H., & Costill, D.L. (Eds.). (1998). *Fisiología del esfuerzo y del deporte*. Barcelona: Paidotribo.

Williams, C.A., Oliver, J.L., & Faulkner, J. (2011). Seasonal monitoring of sprint and jump performance in a soccer youth academy. *International Journal of Sports Physiology Performance*, *6*(2), 264-275.

Williams, A.M., & Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Science*, *18*(9), 657-667.

Wisløff,U., Helgerud, J., & Hoff, J. (1998). Strength and endurance of elite soccer players. *Medicine & Science in Sports & Exercise, 30*(3), 462-467.

Wong, P.L., Chamari, K., Dellal, A., & Wisløff, U. (2009). Relationship between anthropometric and physiological characteristics in youth soccer players. *Journal of Strength and Conditioning Research, 23*(4), 1204-1210. doi: 10.1519/JSC.0b013e31819f1e52

Wong, P.L., Chamari, K., & Wisløff, U. (2010). Effects of 12-week on-field combined strength and power training on physical performance among U-14 young soccer players. *Journal of Strength and Conditioning Research*, *24*(3), 644-652. doi: 10.1519/JSC.0b013e3181ad3349

Wragg, C. B., Maxwell, N. S., & Doust, J. H. (2000). Evaluation of the reliability and validity of a soccer-specific field test of repeated sprint ability. *European Journal of Applied Physiology*, *83*(1), 77-83.

Würch, A. (1974). La femme et le sport. *Médecine Sportive Francaise, 4*(1).

Zubero, J. (2010). *Goi mailako futbolari gazteen ezaugarri antropometriko eta fisiologikoen garrantzia aukeratze-prozesuan.* (Doctoral dissertation, University of the Basque Country, Department of Physiology, Faculty of Medicine and Dentistry, Basque Country).

Zubero, J., Gravina, L., Ruiz, F., Irazusta, J., Gil, F.J., Kortajarena, M., & Gil, S.M. (2007). Desberdintasun antropometriko eta fisiologikoak Athletic Club fundazioko sorbideetako eta talde lokaletarako 10-14 urteko jokalarien artean. In J. Castellanos & O. Usabiaga (Eds.), *Jarduera fisikoa eta kirola ikertuz II* (pp. 291-307). Gasteiz: Euskal Herriko Unibertsitateko argitalpen zerbitzua.

Zubillaga, A., Gorospe, G., Hernández Mendo, A., & Blanco Villaseñor, A., (2007). Match analysis of 2005-06 Champions League Final with Amisco system. In F. Korkusuz & E. Ergen, (Eds.), *Book of abstracts VI th World Congress on Science and Football* (pp. 20). Antalya/Turkey.

9. Eranskinak

I.ERANSKINA

ARGITARAPENAK

Orain arte tesi hau burutzeko erabili diren datuekin argitaratu diren artikuluak eta kongresu desberdinetan aurkeztu diren lanen zerrenda:

ARTIKULU ZIENTIFIKOAK

Bidaurrazaga-Letona, I., Lekue, J.A., Amado, M., Santos-Concejero, J., & Gil, S.M. (2015). Identifying talented young soccer players: conditional, anthropometrical and physiological characteristics as predictors of performance. *International Journal of Sport Science.* [Epub ahead of print]

Bidaurrazaga-Letona, I., Carvalho, H.M., Lekue J.A., Santos-Concejero J., Figueiredo, A.J., & Gil, S.M. (2014). Longitudinal field test assessment in a Basque soccer Youth Academy: a multilevel approach. *International Journal of Sport Medicine,* 2014 Nov 27. [Epub ahead of print]

Carvalho, H.M., Bidaurrazaga-Letona, I., Lekue J.A., Amado, M., Figueiredo, A.J., & Gil, S.M. (2014). Physical growth and changes in intermittent endurance run performance in young male Basque soccer players. *Research in Sports Medicine, 22*(5): 553-559.

Bidaurrazaga-Letona, I., Badiola, A., Granados, C., Lekue, J.A., Amado, M., & Gil, S.M. (2014). Relative age effect in soccer: a study in a professional Basque club. *Retos. Nuevas tendencias en Educación Física, Deporte y Recreación, 25*:95-99**.**

KONGRESUAK ETA ARGITARAPENAK

Bidaurrazaga-Letona, I., Carvalho, H.M., Lekue, J.A., & Gil, S.M. Age related differences in agility during a training season in youth elite soccer players. *19th annual Congress of the European College of Sports Science*, Amsterdam, 2014. Laburpen liburua: ISBN 978-94-622-8477-7, 2014.

Bidaurrazaga, I., Lekue, J.A., Amado, M., & Gil, S.M. Anthropometry and physical performance in young soccer players according to their maturity status and chronological age. *18th annual Congress of the European College of Sports Science*, Barcelona, 2013. Laburpen liburua: ISBN 978-84-695-77861-8

Bidaurrazaga-Letona, I., Lekue, J.A., Amado, M., Granados, C., Santos-Concejero, J., & Gil, S.M. Continuity of young soccer players in a professional club. *18th annual Congress of the European College of Sports Science,* Barcelona, 2013. Laburpen liburua: ISBN 978-84-695-77861-8

Bidaurrazaga-Letona, I., Antropometría y rendimiento físico en jóvenes jugadores en relación con la maduración y la edad cronológica. *XVII Curso de la Asociación española de médicos de equipos de fútbol*, Bilbao, 2013.

Bidaurrazaga-Letona, I., Badiola, A., Granados, C., Lekue, J.A., Amado, M., & Gil, S.M. Relative age effect in male and female soccer players of different categories in a professional club. *IV Congreso Nacional de Ciencias del Deporte y la Educación*, Pontevedra, 2013. (*Poster birtual onenaren saria*).

Bidaurrazaga-Letona, I., Badiola, A., Santos, J., Gravina, L., Amado, M., Lekue, J.A. & Gil, S.M. Goi mailako futbol jokalari gazteen hezur adina, ezaugarri antropometrikoak eta errendimenduzkoak denboraldi baten zehar. Idisport, *Congreso Internacional en Ciencias de la Actividad Física y el Deporte. Investigación, Desarrollo e Innovación,* Vitoria- Gasteiz, 2011. Laburpen liburua: ISBN 978-84-9910-197-2

Bidaurrazaga, I., Gravina, L., Lekue, J.A., Amado, M., & Gil, S.M. Rendimiento en futbolistas jóvenes: relación con la edad cronológica y ósea, testosterona y dehidroepiandrosterona. *XIII Congreso Nacional de la Federación Española de Medicina del Deporte*, Bilbao, 2011. Laburpen liburua: ISSN 0212-8799

Gil, S.M., Bidaurrazaga, I., Lekue, J.A., Amado, M., Badiola, A., & Figueiredo, A. Physical characteristics, performance and skeletal age in 10-11 year old soccer players of a professional club. *15th congress of the European college of sport science*, Antalaya, 2010. Laburpen liburua: ISBN 978-605-61427-0-3

Gil, S.M., Bidaurrazaga, I., Lekue, J.A., Amado, M., Badiola, A. & Figueiredo, A. Performance is more related to chronological age than maturity in soccer players aged 10-11. *15th congress of the European college of sport science*, Antalaya, 2010. Laburpen liburua: ISBN 978-605-61427-0-3

.

II.ERANSKINA

COMITÉ ÉTICO DE INVESTIGACIÓN CLÍNICA

ASISTENTES

PRESIDENTE
D. Alberto Alonso Ruiz

VOCALES
D. Luis Villoldo Ortega
D. Francisco Javier Santamaria Sandi
D. Francisco Javier González Mielgo
D. Manuel Zaballa Iñiguez
D. José Ramón Bilbao Catalá
Dª. Susana Fernández Gallastegui

SECRETARIA
Dª. Amaya Martínez Galarza

ACTA 8/08

En Cruces-Barakaldo, el día 30 de Septiembre de 2008, a las 15 horas 30 minutos, se reúnen los miembros del Comité señalados al margen. Excusan su asistencia D. Adolfo González Calles, D. Jesús M. Morán Barrios y D. José Ignacio Pijoán Zubizarreta. Se trataron los siguientes temas:

IV-LECTURA DE DOCUMENTACIÓN RECIBIDA

a) Carta de la Dra. Gil Orozco/Instituto Vasco de Educación Física de la UPV/EHU investigadora del estudio **"Parámetros Antropométricos y Fisiológicos de futbolistas jóvenes en desarrollo: importancia de la selección en futbolistas jóvenes de alto nivel"** (**código CEIC E05/01**) en la que presenta la Enmienda nº 1 versión de fecha 24 de Junio de 2008 y adjunta la Hoja de Información y Consentimiento Informado para los jugadores y jugadoras mayores de edad versión de fecha 24 de Junio de 2008, Hoja de Información y Consentimiento Informado para los jugadores y jugadoras menores de edad y sus tutores/responsables versión de fecha 24 de Junio de 2008. Una vez revisada la documentación, este CEIC decide **AUTORIZAR** la citada documentación aunque tiene que realizar la siguiente consideración:

- Hojas de Información: (todas)
  - Se debe reflejar que el estudio se realizará según la Ley Orgánica 15/1999 de Protección de Datos de Carácter Personal, máxime en lo que concierne al envío y manejo de datos a terceros
  - Se debe reflejar que el estudio cuenta con la preceptiva autorización del Comité Ético de Investigación Clínica del Hospital de Cruces

Asimismo, se recuerda a la investigadora que debe informar al CEIC del desarrollo e incidencias del estudio durante su realización, así como de la finalización del mismo, con la presentación del Informe Final.

Sin más temas por tratar, se da por finalizada la reunión a las 18 horas 30 minutos del día señalado al principio.-

Osakidetza
Servicio vasco de salud
GURUTZETAKO OSPITALEA
HOSPITAL DE CRUCES

LA SECRETARIA

III.ERANSKINA

<u>DATOS PERSONALES:</u>

APELLIDOS:

NOMBRE:

FECHA ACTUAL:

Numero de teléfono de contacto: Teléfono domicilio:

<u>HISTORIAL:</u>

-Fecha de nacimiento: Edad:

-**Antecedentes médicos**:

-¿Has tenido alguna enfermedad importante?

-Lesiones (indica cuál, cuándo ocurrió y cuánto tiempo estuviste sin entrenar o jugar)

-¿Tomas alguna medicación?

-**Antecedentes familiares**:

- Altura de la madre:

-Altura del padre:

-**Antecedentes deportivos:**

-¿Cuántos años llevas jugando al fútbol?

-¿Anteriormente al fútbol jugabas a futbito/fútbol 7 etc? Cuántos años?

-¿Desde cuándo estás en el Athletic?

-¿En qué otros equipos has jugado? Indica cuánto tiempo en cada equipo

-¿Eres zurdo/diestro de mano?

-¿Eres zurdo/diestro de pierna?

-¿En qué puesto sueles jugar?

-¿Has estado alguna vez jugando para la selección de Euskadi/España? Indica cuándo.

-¿Realizas algún otro deporte (indica cuál)? Con que regularidad?

ANTROPOMETRIA

IZEN ABIZENAK: **DATA:**

Pisua (kg):	Altuera (cm): Altuera jezarrita (cm):

Azal tolesturak (mm):

				Bataz bestekoa
Trizipitala				
Subeskapularra				
Suprailiakoa				
Abdominala				
Izterra Jezarrita				
Zangoa Jezarrita				

Perimetroak (cm):

				Bataz bestekoa
Beso erlaxatua				
Beso uzkurtua (90º)				
Izterra (zutik)				
Zangoa (zutik)				

Diametroak (cm):

				Bataz bestekoa
Ukondoa				
Eskumuturra				
Belauna				
Orkatila				

HANDGRIP PROBA

	I. **Saiakera**	**2. Saiakera**		**Bataz bestekoa**
Handgrip				