Analysis of Small Sided Games training in Elite Youth Soccer Players

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A thesis submitted in partial fulfilment of the requirements of Edinburgh Napier

University, for the award of Masters by Research

November 2015

Consent Statement

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Abstract

The aim of this study was to investigate small sided games (SSGs) field size (small, large) effect on elite youth soccer players. Analysing differences in youth age group players physiological performance and time and motion responses according to field size, through the mean of global positioning system (GPS).Data was collected from ninety six (N=96) elite youth soccer players (aged 10.4± 0.2 years -16.2± 0.5 years; height 142.4±5.8cm -179.1±4.7cm; body mass 33.6±4.2kg-69.9±6.5kg) serving as participants in this study aged u11, u12, u13, u14, u15, u16/17. Player measurement of physical responses and GPS time and motion external workload categories and RPE responses were recorded during 4v4 SSGs 3x3min on small field size 20x20m and large field size 40x40m, with 1.30 min active recovery .

All players completed the RPE Scale (Rate Perceived Exertion) assessment the Borg 6-20 - point scale, validated within studies, as a measurement method of perceived exertion giving valid indication of exercise intensity (Chen, 2002). It was hypothesised SSGs small field size would elicit greater task intensity in players physical and time motion responses compared to SSGs large field size. SSGs performance was reported as total distance covered (metres), metres covered per minute, maximum velocity, with data reported as both absolute (m) and relative (m · min -1) relevant speed zones for age groups were applied, as applied and validated in previous research studies. (Harley, Barnes, Portas Lovell. Barrett and Paul, 2010).Results showed a significant main effect Youth Age Groups distance covered per minute $F_{(2,94)} = 7977.4$, p = <0.01, $\dot{\eta}^2 = .970$, $w^2 = 2.13$,mean±SD 1166±9.5),metres covered per minute $F_{(2,94)} = 6941.7$ p = <0.01, $\dot{\eta}^2 = .988$, $w^2 = 2.262$, mean±SD125±1.6),maximum velocity speed ($F_{(2,94)} = 7977.4$,p = <0.01, $\dot{\eta}^2 = .990$ $w^2 = 305.8$,mean± SD 6.4±.046);

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%HRmax ($F_{(2,94)}$ =4169.7 P=0.01 , $\dot{\eta}^2$ =.980,w²=1.25, mean ± SD 94.8±.36); RPE ($F_{(2,94)}$ = 819.0,P=.001, $\dot{\eta}^2$ =.907, w²=1.25,mean±SD18.2±.463),and a statistically significant main effect Field Size distance covered ($F_{(2,94)}$ =2972.5, P.001,w²= 1.91), metres covered per minute ($F_{(2,94)}$ =2862.0,P.001,w²=1.82),maximum velocity ($F_{(2,94)}$ =810.6.P.001,w²=347.0), %HRmax ($F_{(2,94)}$ = 280.0,P.001, w²=6.24),RPE ($F_{(2,94)}$ =39.4.P.001, w²=8.92).

It was further shown a significant interaction effect, indicated effect of field size influenced youth age group distance covered ($F_{(2,94)} = 15.4$, P.001, $w^2 = 394.1$), metres covered per minute ($F_{(2,94)}=28.7$ P.00,1 $w^2 = 188.7$), maximum velocity ($F_{(2,94)}= 6.920$, P.001, $w^2 = 560.6$), %HRMax ($F_{(2,94)}=41.2$, P. 001, $w^2 = 43.3$), RPE ($F_{(2,94)}=969$, P.001, $w^2 = .0156$). Findings show significant main effect Youth Age Groups and Field Size, with mean values differing significantly large field compared to small field. A significant interaction effect showed field size influenced youth age groups mean values. Findings show physiological and time motion responses increased significantly as field size increased, regardless of player age. Large field promoted greater physiological and time motion performance.

ACKNOWLEDGMENT

For mentorship displayed throughout this project I would like to give thanks and acknowledgement to my supervisors Dr Tony Westbury and Dr Geraint Florida James for guidance and patience.

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1.0 Introduction

1.1 Rationale for research study

Within studies the youth soccer player has not extensively been studied compared to adult players (Castagna et al., 2003: Harley et al., 2010).Studies examining youth soccer players physical and time motion performance in an across age range group analysis are limited (Goto et al., 2013). Recognising youth soccer player's physical and time motion demands in relation to player age, is important to allow individual weaknesses and strength needs to be addressed relative to game demands, further allowing for development within age specific soccer training. Limited information in competitive games, SSGs and training performance exists for elite youth soccer players aged 9 to 16 years in relation to running efforts and speeds achieved, having this relevant information would allow greater understanding of distance covered load and running speed thresholds. Measurements of youth player workload responses provides access to valuable information, relative to physiological responses and potential achievement in relation to player development, talent identification and therefore help to show how training should be structured.

In comparison to adult soccer players, it has been found elite youth soccer players, physiologically, have lower values in maximal oxygen uptake (Stolen et al., 2005) .Having higher values within $\dot{V}O_2$ levels enables a player to run larger amounts of total running distance (McMillan et al., 2005),It was further shown greater $\dot{V}O_2$ levels and total distance sprinted in elite youth soccer players were reached within SSGs (Dellal et al., 2011), allowing improvement in physical performance, aerobic capacity, repeat sprint ability, technical skills and tactical abilities. Dellal et al., (2011) further suggested SSGs offer an ideal alternative for optimising soccer specific

physical fitness training components, technical and tactical abilities of elite youth players other than traditional physical training processes and running regimes.

Scientific literature has recognised the popularity of SSGs application to support physical development of adult players (Impellizzeri et al., 2006; Reilly et al., 2004), further, evidence and validation within empirical studies, demonstrate professional teams have achieved success through application of continued SSGs usage (Strøver et al.,2004), showing SSGs are suitable for eliciting workload intensities which develop soccer endurance and soccer skills at elite levels, and provide physical workload task demands that are suitable for eliciting intensities equal to full sized game workload intensities (Maclaren et al, 1998).SSG are increasingly used as a training method within soccer environments and is considered an effective training method with advantages within improving physical fitness levels, developing technical and tactical skills, and enhancement of player performance. (Hill-Hass et al.,2009,2010).SSGs, can be influenced through applying and altering relative variables such as field size, game rules, game duration, player numbers and coach encouragement, all of which variables have been found to impact player workload actions of activity in SSGs (Abrantes et al, 2012; Dellal et al, 2011; Fanchini, et al.,2010; Koklu, 2012). However, disagreement exists within SSGs research whether SSGs can be effective within improving player's physical performance. Within previous studies, it is believed SSGs did not provide intensity of exercise to increase a soccer players physical performance levels (Little et al., 2007) or not capable of providing sufficient workload demands to allow sufficient development in players physiological mechanisms, which are necessary to improve endurance levels (Hoff et al, 2002: Little et al.,2006).

Little research on youth players within SSGs is available, through investigating SSGs training in elite youth soccer players, it is hoped further knowledge will be gained on the influence of SSGs field size effect and influential variables relative to youth player performance which may add new found knowledge or cover gaps in existing SSGs literature relative to optimising field size to benefit youth player's technical skills and physical development. Which is why, this is an important study because it is a first involving u11, u12, u13, u14, u15, u16&17 professional elite youth players rather than adult players. Researchers have focused and given more attention in previous research literature to adult soccer players in comparison to youth soccer players. However, few studies exist on elite youth soccer players in SSGs field size effect on physical and time/motion responses in SSGs, across a range of age-groups.

1.2 Aim

The aim of this study was to investigate SSGs small field size and large field size effect in elite youth soccer players across a range of age-groups. Investigating physical and time/motion responses, through global positioning system technology, relative to the influence of field size.

1.3 Hypothesis

It is hypothesised small sided games (SSGs) small field size will provide and promote greater physical and time, motion responses within elite youth soccer players in comparison to SSGs large field size.

2 Literature review

2.1 Physical demands of soccer

2.1.2 Adult players

Within a soccer game at adult competitive level, players within an ninety minute 11v11 game on a full sized field of 100x70m,have been shown to cover distances ranging between eight to thirteen kilometres (Bangsbo, 1994; Mohr *et al.*, 2003; Mohr *et al.*, 2008),complete one hundred to five hundred runs of high intensity, of which twenty to forty are maximal sprints, in an average period of every ninety seconds, with sprint durations lasting up to four seconds(Bangsbo et al,1991),This corresponds to a maximal heart rate of 80-90% and VO2^{max} of 75-85% (Stolen *et al.*, 2005).

Adult players can potentially spend up to eleven per cent of a game time sprinting (Van Gool, et al.,1988),this involves up to a thousand short endurance activities, and sprint activities up to ten to twenty metres in length(Mohr et,al,. 2003).Players encounter high levels of running intensity every sixty five seconds, and can make up to sixteen tackles, pass the ball up to thirty times, sustain speed changes, whilst maintaining body control for technical ball control skills (Ekblom,1986).Furthermore, further energy demands are required from players for accelerating, decelerating, jumping, tackling, shooting, dribbling, turning (Bradley *et al.*, 2009;Di Salvo *et al.*, 2009; Mohr *et al.*, 2003; Mohr *et al.*, 2008).

It is further recognised adult player's uptake of maximal oxygen had a range between 55-70 ml O2 min- 1kg.

Within a game, players can experience unpredictable activity, one to every three seconds, which can involve thirty to forty accelerations, up to seven hundred turns thirty to forty jumps and tackles(Bloomfield, et al., 2007;Mohr et al., 2003), this includes high intensity actions of running, dribbling, kicking passes and tackling (Bangsbo, 1994b).

Within games players can reach anaerobic threshold of up to 80–90% of maximal heart rate (Stolen *et al.*, 2005), through bursts of activity involving sprinting, turning, jumping, changes in running pace, and initiating forceful muscle contractions for balance maintenance, performance of technical skills and performance of offensive and defensive pressure with or without ball.

It was recognised (Reilly, 1996) within games ,the movement patterns of players over a distance, involved forward, sideways, backwards and jockeying movements, this decreased player energy levels, compared to normal running. Bangsbo et al,(2008) further found players can perform repeated bouts of intense exercise with up to one thousand intermittent activities occurring, mostly at low intensity, such as walking or standing for up to sixty per cent within a game.

Player performance within soccer games heavily relies on the players aerobic and anaerobic fitness capabilities, such is the intensity and workloads demanded of soccer players, work rate levels sustained within a game of soccer, is dependent on the level of aerobic capabilities, the player can achieve.

2.1.3 Youth players

The youth soccer player in comparison to adult players has physical limitations within anaerobic metabolism as a consequence of having smaller body size and limbs, smaller heart size and lungs, resulting in lower aerobic capacity, and lower cardiac output (Stølen et al 2005). With similar findings Rowland et al.,(1987), recognised youth player's economy of running and walking was lower as a consequence of having shorter legs which require higher stride movement frequency and shorter length of stride.

It has been reported a lack of information still exists in 'trainability' of the youth player population (Naughton et al., 2000). However ,authors have found youth players can cover distances in competitive games of 5 to 8 km, with adult players covering up to 8 to 12 km (Goto et al ,2013;Rebelo et al,2012;Carling et al,2009).

Adult players have higher aerobic capacity levels in cardiorespiratory fitness in comparison to youth players (Bangsbo et al,2006). Influencing factors between youth players and adult players are disparities within capacity of aerobic values and limitation in glycogen storage of youth players. This provides adults players the ability to continually maintain performance workloads for the duration of competitive games (Metaxas et al.,2005). This demonstrates a positive relationship relative to distance covered and aerobic power for adult players within competitive games (Krustrup et al,.2003;Bangsbo et alt.,1992).

Further, it has been found aerobic performance has improved within youth players, when they spend time in high intensity levels of activity, increasing amount of sprint capability, ball touches and quicker recovery times during and after high-intensity efforts of activity (Impellizzer et al., 2005).

Reports have suggested fatigue is associated in soccer players, in response to depletion of glycogen and decreased workloads in distances covered, in the later stages of players in soccer games (Mohr et al.,2005). In comparison to adult players, youth players are limited to how much glycogen they can store ,with only 50-60 %, compared to adults (Alvarado , 2005), as youth players have a glycogen depletion rate faster to adults (Boisseau et al., 2000), which may influence the smaller distances covered by youth players in games.

Research is limited, with little literature addressing depletion of glycogen in youth soccer players, blood sampling and invasive procedures, become ethical issues regards to the youth player population, as a result, fewer studies exist (Naughton et al., 2000). Therefore, differences in energy metabolism in physical exercise between youth players and adult players are still uncertain and not fully known.

Research has established, Nikolaidis (2011) anaerobic power of youth players compared to adult players was found to be fifty percent inferior, during high intensity activity resulting in lower ATP supply, limited phosphofructokinase (PFK) activity and reduced glycolysis (Riddell, 2008).As a consequence of having an anaerobic capacity which is immature, it can be expected, youth players to travel at slower speeds and cover less distance during high intensity efforts (Alvarado,2005).

However anaerobic capacity will improve progressively as youth players age begins to increase, primarily through increased enzymatic activity, gains in muscle mass and body size (Naughton et al., 2000).

Further reported in previous studies was concern in youth player's physiological characteristics relative to impairment of thermoregulatory responses (Di Salvo et al, 2009). In relation to youth players sweating capacity becoming diminished, in

response to players cardiac output being lower and having a large body mass ,with a body surface high in ratio (Rowland ,2007).

Therefore, youth players in comparison to adult players in prolonged competitive games face a disadvantage due to youth player's thermoregulatory responses (Alvarado , 2005). In comparison to adults, elite youth players cover less distance in games, produce fewer frequencies of activities at high intensity, due to maturity status and physiological differences and game playing time being shorter. To date, literature available does not confirm a gold standard selection criteria for analysis of youth players game pattern activities involving walking, jogging, sprinting.

Table 1: Reported distance covered from adult players during a 90 min game.

Study	Players	Distance Covered (km)	
Bangsbo et al. (1991)	1st – 2nd Division (Denmark)	10.8	
Strudwick and Reilly (2001)	Premier league (England)	11.3	
Mohr, Krustrup and Bangsbo	1st Division (Denmark)	10.3	
(2003)	1st Division/Champions league	10.9	
	(Italy)		

 Table 2: Reported distances covered from elite youth players during games.

 (Buchheit ,Mendez,Villanueva,Simpson,Bourdon,,2010)

	u/13	u/14	u/15	u/16	u/17	u/18
Distance Covered (km)	6.5	7.1	8.0	8.2	8.4	8.6
Playing Time	2x35 min	2 × 35 min	2 × 40 min	2 × 40 min	2 × 40 min	2 × 45 min

2.2 The use of small sided games in preparation for full sided games

SSGs can also be known in terms as game based training and skill based conditioning games (Alexiou et al., 2008;Gabbett, 2006).SSGs are games which are modified and played in reduced modified sized soccer fields, involving adaptation in rules and reduced player numbers in teams compared to traditional eleven v eleven soccer games.SSGs which are implemented in soccer clubs worldwide and are part

of worldwide youth soccer development programmes as found in Holland "s Royal Dutch Football Association and Australian Football Association (Malina, 2003)

SSGs evolved from unstructured games of street soccer, which introduced some of the top players to soccer informally through street, playground, beach and local park soccer (Football Federation Australia,2010).Now within soccer club settings worldwide, a more structured approach in SSGs delivery is adopted (Football Federation Australia,2010). SSGs in soccer is considered a leading popular training modality due to its practicality and advantages in its application to all age levels ranging from youth to adult soccer levels.

SSGs are found to be beneficial to soccer players primarily due to replication of the physiological intensity demands, movement patterns, technical and tactical requirements similar to competitive game play, placing players in offensive and defensive game related situations, requiring and provoking decision making of players, with players reaching maximum heart rate max of ninety – per cent (Gamble, 2004; Reilly et al., 2004; Williams, et al., 2003).

A player's physiological development from youth player to adult player can be very demanding, improving physical and technical performance, can define the potential performance level or standard of play reached from that player (Bangsbo, 1994). In comparison to fitness training programmes ,SSGs are believed to improve and increase player motivation, and player compliance ,through players perceiving SSGs as more sports specific and furthermore it is considered SSGs provide better time efficiency in comparison to other fitness training due to development of technical skills, tactical awareness ,physical performance (Gregson et al.,2000).

Hoff et al., 2002 found SSGs were capable of developing endurance fitness levels and technical ability, contributing to physical development, allowing movement

patterns similar to competitive soccer, and more appropriate for developing physical training loads of players which are more specific to soccer (MacLaren et al.,1988;Williams et al.,2003),causing players to encounter higher intensity workload demands and are able to maintain higher heart rates and remain longer within heart rate zones (Hill-Haas et al.,2010).

Over previous years a large growth of SSGs research has recognised and established SSGs can be considered an effective training method, which can be manipulated to allow development of players technical, tactical abilities, whilst providing physical stimulus for improving fitness levels (Gabbett et al.,2008),

Most existing research literature has investigated adult soccer players in comparison to youth soccer players. It has been reported dating back to 2006, there are twenty-two million youth players around the world playing soccer Kunz, (2007). Youth soccer players are not miniature adult players, in comparison to adult players they possess smaller heart, lungs, body composition, lower anaerobic and aerobic capacities, and limitation in glycogen storage for games.

However, few studies exists on elite youth soccer players in SSGs field size effect and physical, time/motion responses in small and large fields, across a range of age youth groups. In an attempt to improve aerobic and anaerobic fitness of players, while improving technical abilities, validated research demonstrates, soccer coaches worldwide will apply training adaptations such as SSGs (Rampinini et al, 2006; Hill-Haas et al., 2009).

Yet, previously it was believed SSGs did not provide intensity of exercise to increase a soccer players physical and technical performance levels (Little et al., 2007) or not capable of providing sufficient workload demands to allow sufficient

development in players physiological mechanisms, which are necessary to improve optimal endurance levels (Little et al., 2006).

The objective of this study was to investigate SSGs field size training effect in elite youth soccer players across a range of age youth groups. Investigating physical and time/motion responses, through global positioning system technology, relative to influence of field size. It is hypothesised within small sided games (SSGs) small field will elicit greater task intensity in players physical and time motion responses.

Recognising a soccer player's time and motion characteristics is now a common wide spread practise, utilisation of software technology such as global positioning systems (GPS) allows practitioners to monitor and measure within training, players patterns in movement demands (Aughey 2011). Within soccer, players frequently encounter, the demand to accelerate, decelerate and travel distances within performance workloads (Young et al.,2012), accuracy within measurements of workload demands is important, practically for practitioners and support staff (Akenhead, et al.,2013).

2.2.1 Rate of perceived exertion influence

It has been shown within studies, RPE (rate of perceived exertion) within soccer is an is an excellent indicator of intensity of exercise load players experience within soccer (Impellizzeri *et al.* 2004). It was found SSGs formats involving 1v1s, 2v2s, 3v3 ,4v4 and 5v5s on large field size area had a more significant player self-rating score of RPE ,compared to SSGs on small field size . Findings are in accordance to similar findings established within previous SSGs research, identifying as field size increased ,as did volume of intensity of player work load increased, as did players

perception of exertion(Dellal et al., 2012;.Casamichana et al.,2010;Rampinini *et al.*(2007).Authors suggest RPE is a reliable source for providing instant RPE marker feedback allowing for instant recognition of exercise intensity workloads placed on player within SSGs, allowing for an instant accurate reflection of players perceived exertion.

2.3 Elite youth player physical characteristics

With youth players having an anaerobic capacity which is immature, and a lower body fibre muscle maturation distribution (Naughton et al.,2000), it can be expected for youth players to travel at slower speeds in activities of high intensity (Alvarado,2005). Volumes of research has examined physical characteristics of elite adult soccer players (Clark et al., 2008; Dunbar et al.,1997;Edwards et al., 2003;Zerguini et al.,2007). However, in contrast, there is limited investigation in elite youth soccer players in categories involving variation in age groups (Chamari et al.,2004; Helgerud et al., 2001;Reilly et al.,2000).

Physiological factors in metabolic differences between youth players and adult players in soccer can be down to youth players having lower economy of walking and running due to smaller legs, requiring a high stride frequency during high workload demands, with youth players having a stride length which is smaller compared to adult players (Rowland et al., 1987).

Further youth players display running mechanics which is less efficient, such as greater braking forces, high peak ground reaction forces (Ebbeling et al., 1992; Grieve, et al., 1966), furthermore youth players have an imbalance of mass-speed,

effectively youth players cannot match body load to the imposed movement speed.(Davies, 1980; Thorstensson, 1986).

The chronological age of players recruited and found in previous youth soccer research studies range from 12-18 years. Furthermore it has been highlighted insufficient information exists in variation of pre-pubertal age range groups.(Chamari et al., 2005; Helgerud et al., 2001; Reilly et al., 2000).

Studies have reported physical performance and physical characteristics between adult premier league players and elite youth players of sixteen years having similar body fat, body mass, flexibility, 20m sprint, maximal oxygen uptake, and repeated sprint ability (Reilly et al., 2000).

Most elite youth soccer player's research studies examine physical performance and physical characteristics of players aged 12-16 years, with limited studies on younger player measurements and in competitive games existing. However both Capranica et al.,2001 and Castanga et al., 2003 ,reported on elite youth u/11s players from Italy and two top elite club youth teams u/12s and u14s players from Denmark (Stroyer et al., 2004).Match analysis reported mean difference for u/11 Italian youth players for distance covered in competitive games as 4344 m for 0-8 km·h-1, 986 m at medium intensity running, 468 m at high intensity running and 114 m at max intensity running (Castanga et al., 2003).

Whilst, it was further reported elite youth Danish players with a chronological mean age between 12.6 and 14.0 years spent thirty one per cent and thirty four per cent of game time jogging and seven per cent and nine per cent of game time spent at high intensity running (Stroyer et al., 2004), no comparisons of players time within speed zones was included in analysis.

Extensive literature is available in physical performance testing of adult senior players (Dumbar et al.,1997;Wisloff et al., 1998),as like adult players, elite youth players are continually monitored through performance testing (Le Gall et al., 2010).However few limited studies examining field testing on elite youth players as valid game performance indicators exists (Castagna et al., 2009;2010).

Research has shown elite youth players mean body mass increases progressively through chronological age for 30.8kg for 9.2 years of age (Hulse, 2010) through to 73.0kg for players aged 18.1 years (Helgerud et al., 2001)verses 70.0-80.0 kg body mass for elite adult players.

Building an elite youth player physical characteristics profile through conducting fitness testing and anthropometric measurement provides measurement of player's weaknesses and strengths, whilst allowing talent identification and recognising players not meeting required demands (Reilly et al., 2000).

Authors have found while investigating physical performances and physical characteristics of elite youth players and adult players, within field testing on fitness components and anthropometry measures involving , body mass, height, body fat, sprint speed, repeated sprint ability, power, endurance, strength and flexibility, showed a gradual increase of height and body mass in elite youth players occurring in chronological ages from 9 to 18 years, with mean height ranging from 135.2cm for players aged from 9.2 years (Hulse, 2010) through to 181.3 cm for players aged 18.1 years (Helgerud et al., 2001), verses 175-180 cm mean standing height of adult soccer players.

Previous research shows elite youth soccer players mean sprint time increased progressively through chronological age range, from 2.04 seconds for 9.2 years of age in covering 10 metres, to 1.70 seconds for players aged 18.1 years (Hulse,

2010),verses 1.76 seconds for elite youth soccer players (Zerguini et al., 2007), 3.70 seconds for 9.2 years of age in covering 20 metres, to 2.97 seconds for players aged 18.1 years (Hulse, 2010,),verses 3.00 seconds for adult soccer players (Wisloff et al., 2004).

Within other reported findings it was identified chronological age did not influence mean sprint time between 13 and 16 year old elite youth players in two separate research studies, mean sprint time of 4.30 seconds for 13 years of age in covering 30 metres (Vaeyens et al., 2006), verses to 4.48 seconds for players aged 16 years (Reilly et al., 2000), verses 4.00 seconds for adult soccer players (Wisloff et al., 2004).

The estimated oxygen uptake $\dot{V}O_2$ levels of elite youth soccer players increased progressively through chronological age group range, $\dot{V}O_2$ levels 41.2 ml·kg-1 • min-1for 9 year old age group (Hulse, 2010) through to $\dot{V}O_2$ levels 69.8 ml·kg-1 • min-1 for players aged 17 years group (McMillan et al., 2005b), verses VO_2 levels 52.7 to 67.6 ml·kg-1 • min-1 for elite adult players (Wisloff et al., 1998).

Estimated oxygen uptake has been investigated in previous research in assessing and profiling elite player's physical characteristics, with the multi-stage fitness test most employed method in assessing estimated peak oxygen uptake (Ramsbottom et al.,1988), and treadmill laboratory tests and track run tests (Chiara et al., 2005).

It has been reported the Yo-Yo intermittent recovery test allows for more validity in providing indicators relative to a player's soccer specific aerobic levels of fitness and patterns of activity specific to games, than predictions within laboratory or field assessments within peak oxygen uptake (Svensson et al.,2005).

Little research is available in the Yo-Yo intermittent recovery test involving youth soccer players, however ,a study was conducted with elite youth players involving San Marino Youth Academy, reporting players aged 14 covered within Yo-Yo tests a distance of 842 (± 352) metres (Castagna et al., 2009),in comparison to elite adult soccer international players covering 2190 metres ,moderate elite adult players covering 2030 metres ,sub-elite adult players covering 1810 metres in the Yo-Yo intermittent recovery test level 1,and within the Yo-Yo intermittent recovery test level 1260 metres, moderate elite youth players covered 1050 metres and sub-elite youth players covered 840 metres (Bangsbo et al., 2008).Further research is required on elite youth soccer players within Yo-Yo intermittent recovery testing, to allow for further investigation and examination of elite youth soccer players endurance ability.

2.4 Small sided games physiological demands

Previous studies (Katis et al.,2009 ;Tessitore et al.,2006). further support SSGs for inducing sufficient heart rate, maximal uptake of oxygen and stimulating physiological responses within adults and elite youth players ,within findings it was shown 3v3s offered higher physiological response in relation to 6v6 with heart rate values increasing. Hill-Haas et al,(2009),found higher intensity workloads in SSGs of 2 vs. 2 stimulated higher significant heart rate responses compared to 4v4 and 6v6 SSGs ,therefore giving suggestion 2 vs 2 can be used to increase aerobic fitness (Hill-Haas et al,2009). However it is recognised, reliability of SSGs methodology involving larger player numbers influencing responses of physiological game level

intensities may be unsuitable for maximizing soccer specific game development of aerobic fitness intensity levels.

A cause of lower physical responses involving larger player numbers in SSGs, is the consequence of less space and a closer proximity to fellow team mates, causing a reduction in player workload responses, resulting in less opportunity to generate high intensity efforts, as would be encountered with lower player number teams..

In an attempt to improve aerobic and anaerobic fitness of players, whilst also improving technical abilities, coaches will adopt a variety of SSGs field sizes, and apply adaptations involving multi-goal games, manipulate player numbers to elicit higher physiological responses within heart rates, RPE (Rampinini et al, 2006; Hill-Haas et al., 2009).

Within SSGs training sessions, intensity of a players exercise will vary and overlap between aerobic and anaerobic systems, changes within heart rate and volume of blood are results of aerobic training allowing players to have gains in higher maximum oxygen uptake (Ekblom 1969).Soccer players perform anaerobic training to improve their ability of performing repeated bouts of high intensity exercise within games. Anaerobic training will improve player's ability to produce power and force quickly, enhancing potential sprinting ability.

SSGs training, contributes to high demands of physical fitness, in order for a player to be able to perform and produce workloads of a high intensity, the aerobic and anaerobic capacity of the player must have the ability to minimise fatigue, and technical errors, through players having trained aerobic and anaerobic capacities, which will allow players to have ability to endure intense demanding workloads such as performing repeated maximal runs.

Aerobic and anaerobic demands are encountered from players within SSGs training, studies have examined player generated physiological stress loads imposed on players in relation to developing improvement within aerobic fitness levels in SSGs,findings have shown players reaching maximum heart rate of ninety to ninety five per cent, which is recognised as enhancing a soccer player's soccer endurance capacity, and further developing, tactical and technical abilities, that are transferable and specific to match conditions (Impellizzeri et al.,2006;Dellalet al.,2008;Hill-Haas et al,2009).

The format in which SSGs are delivered in training sessions can influence physiological responses, it is recognised in elite performance soccer the benefits of maximum exercise are more achievable when stimulation of exercise in SSGs training is more specific and related to demands of competitive games (Mallo et al., 2008).

Widely recognised in studies (Hoff, et al, 2002), is that physical training factors can be applied in a more soccer specific training environment rather than plain running regimes, integration of SSGs relates physical ,technical and tactical game related practices and training objectives, whilst improving technical ,tactical and physical requirements specific to competitive games (Hoff, et al, 2002).

The modification and adaptation of SSGs training allows technical and tactical components in conditions related to a competitive soccer game, allowing for the player to take the physical training, technical and tactical principles into a transferable competitive soccer game environment (Williams et al.,2003).

Previous thinking was SSGs were not capable of providing sufficient workload demands and intensities of exercise to allow sufficient development in physiological mechanisms, which are necessary to improve endurance levels (Hoff,

2001).However, it is now recognised SSGs are capable in improving and developing endurance and technical ability, vastly contributing to player's physical development (Hill-Haas et al 2009).

Additional benefits of SSGs are a large number of factors influence and are related to individual performance to enable successful outcomes in player competence in demonstrating technical and tactical abilities, physical fitness, which is vital to allow successful outcomes, technical abilities such as passing, control, shooting, making tackles, are all reliant on characteristics of players physiological requirements in relative to muscular strength, aerobic and anaerobic level of fitness,speed,explosive power and flexibility.

2.5 Summary

This thesis is expected to offer, new found additional knowledge to current existing body of literature, relevant to SSGs field size area offering potential for players, to maximise optimal benefit within physical and technical performance.

Knowledge is offered, both SSGs large and small field size areas have potential to influence and restrict player performance, in response to increased or decreased areas of field space.

Large field size areas potentially provide increased available field areas of space, allowing for longer gate strides within player running technique. This provides opportunity for optimal running performance benefits in accumulating maximum velocity speeds, total distance covered and metres covered per minute.

Additional knowledge is offered, SSGs small field size, potentially restricts running performance, in relation to preventing speed and distance accumulation, in

response to players encountering less space. Limitations are placed upon gate stride length, resulting within running patterns of shorter running and dynamic movement. An inability to obtain optimal running performance occurs, through restriction within player ability to accelerate quickly, in response to closer proximity to opponents and team mates, resulting within angled running, preventing opportunity to accumulate increases in acceleration to achieve maximum velocity speeds.

Further additional knowledge is offered, SSGs large field size, is more beneficial to the younger youth player, in early stages of development, regarding developing technical skills, game awareness. Larger field area, allow a player, increased time to think, provide greater proficiency in decision making, in response to greater distances from opposition players and bigger available field space.

Whereas SSGs small field size, encourage players to remain stationary, to demonstrate less game awareness knowledge within decision making ability, on how best to evade markers and create space. Further knowledge is offered, technical skills involving dribbling, become impaired, in response to decreased space, preventing dribbling opportunities. Whilst, passing opportunities increase, as a consequence of decreased field space. As a result, team mates become closer in vicinity to receive a pass.

2.6 Adult player small sided game demands

2.6.1 Field size adults

SSGs research discovered varying field size dimensions within adult SSGs stimulates different physiological responses (Rampinini *et al.*,2007). The quality of evidence within literature appears to have inconsistencies within findings and therefore difficult to compare due to varied field sizes applied in studies. Research show an abundance of different adopted methodologies within studies on small, medium and large field sizes(Hill-Haas et al 2009) and claims a coach can influence SSGs workload intensity, through modifying small, medium and large field dimensions (Rampinini *et al.*, (2007). Reported findings suggested reduction within smaller playing dimensions can provide greater \dot{VO}_2 level responses and increased aerobic capabilities (Tessitore *et al.*, 2006).

Kelly et al.,(2008), reported, within large fields, players face fewer demands to encounter and perform at greater intensities as opposed to small field. Whilst recognising no difference in heart rate response when comparing SSGs played on small and large field. However other studies disagree, Rampinini *et al.*, (2007) discovered SSGs on large playing fields increased heart rate values opposed to small and medium fields, finding large field's stimulated greater aerobic demands, increased heart rate responses and blood lactate level compared to small field. However Rampinini *et al.*(2007) did not isolate important independent variables to allow individual examination of impact of field size , exercise type and coach encouragement ,it can be suggested this limited the studies ability within

differentiating variables that clearly impact players physiological response within SSGs.

Research indicates , Rampinini et al.(2007), increased and decreased field size can directly influence player performance in SSGs. Enhancing or restricting player activity and motion movement patterns in relation to physiological and technical workload (Araújo et al.,2006). However, studies disagree in influence of correct field dimensions best applied (Rampinini et al.2007). The origin of disagreement being based upon correct field dimension applied to elicit physical, perceptual and time motion responses. It is recognised previous studies in literature has employed various SSGs format approaches regarding field size dimensions, with studies finding conflicting differences. To date research is undecided as to either small field or large field is more significant in providing physical and time-motion demands in SSGs (Aguiar *et al.*, 2012).

Study	SSGs	Field Size	Time	Heart Rate	Distance Covered (m)
Jones & Drust (2007)	4 v 4	30 x 25 m	10 min	175 bpm	778 m
	8 v 8	60 x45 m	10 min	168 bpm	693 m
Hill-Haas et al. (2009)	2 v 2	28 x21 m	24 min	89% HRmax	2574 m
	4 v 4	40 x30 m	24 min	85%HRmax	2650 m
	6 v 6	49 x37 m	24 min	83%HRmax	2590 m
Little & Williams (2007)	2v2	30 x20 m	4 x 2 min	89%HRmax	
	3v3	43 x25 m	4x3.30min	91%HRmax	
	4v4	40 x30 m	4 x 4 min	90%HRmax	
	5v5	45 x30 m	4 x 6 min	89%HRmax	
	6v6	50 x30 m	3 x 8 min	88%HRmax	
	8v8	70 x45 m	4 x 8 min	88%HRmax	
Rampinini et al. (2007)	3v3	12 x20 m	4 min	87%HRmax	
	3v3	15 x25 m	4 min	88%HRmax	
	3v3	18 x30 m	4 min	89%HRmax	
	4v4	16 x24 m	4 min	86%HRmax	
	4v4	20 x30 m	4 min	86%HRmax	
	4v4	24 x36 m	4 min	87%HRmax	
	5v5	20 x28 m	4 min	86.%HRmax	
	5v5	25x35m	4 min	86.1%HRmax	
	5v5	30x42m	4 min	87.9.%HRmax	
Mallo &Navarro (2008)	3v3+1	33 x 20 m	5 min	173 bpm	747 m
	3v3+2	33 x 20 m	5 min	173 bpm	749 m
	3v3+3	33 x20 m	5 min	166 bpm	638 m
Kelly & Drust (2009)	5v5	30x20m	4 x 4 min	175 bpm	
,	5v5	40x30m	4 x 4 min	173 bpm	
	5v5	50x40m	4 x 4 min	169 bpm	

Table 3: Adult studies in small sided game formats

Interpretation of the above authors summary of studies on SSGs (table 3) suggest 3v3s on medium size fields offers optimizes greatest physiological player workloads for players compared to small and large fields.

Kelly et al., (2009) found no influence on heart rate responses in 5v5 small, medium, large field SSGs formats, it was recognised more technical actions were performed on small field compared to medium and large fields, due to closer proximity of players and goals, allowing more actions and ball contact (Kelly et al, 2009).Findings show altering field size made no significant difference in player heart rates. The face validity of Kelly et al.,(2009) study seem appropriate for intended measurements, however influence of rest ratios may have contributed to lower heart rate responses found in SSGs formats. In accordance with above studies Jones et al.,(2007), further reported no difference between field dimensions, however, findings may have been a consequence of low age in participants used .

However within contrary findings, Rampinini et al. (2007) found heart rate responses in small, medium and large fields significantly different with greater heart rate values reached in SSG played on a large field.

Methodology variations exist with SSGs small, medium and large field size dimensions and therefore drawing a definitive comparison or conclusion in relation to player heart rate responses is difficult. Furthermore SSGs game playing time varies in research studies, resulting within inaccurate comparisons of player responses. To allow true comparisons and isolation of field size effect and influencing factors on players ,can only truly be achieved if applied methodology within field size were of a standardized field size for afore mentioned SSGs small, medium and large field studies. Previous literature (Hill-Haas et al., 2009) investigating SSGs relative to individual player field area and player numbers concurrently continue to suggest increasing numbers of players without increasing relative area of field per individual player, results in lower intensity of exercise. Hill-Haas et al., (2009) reported, on an investigation on twenty amateur soccer players, the influence of increasing SSGs field size area and player numbers simultaneously had on, percentage of heart rate, RPE, it was found intensity of exercise in all SSGs formats decreased when player numbers increased and more relative field area per player was increased. However the studies low subject population limited sampling.

Further findings showed a greater range of exercise intensity and maximum oxygen uptake values were produced in small field compared to lower values produced in large field (Tessitore et al., 2006).

Rampinini *et al.*, (2007) found increased optimal individual playing area, resulted in increased rate of perceived exertion (RPE) when comparing small, medium and large fields. Results in both studies are in accordance to RPE findings in this research study. As according to Steed et al., (1994) greater distance covered normally results in greater RPE.

However in conflicting findings Kelly et al., (2009) found greater RPE responses in small field format compared to medium and large field size. Less distance was covered in small field compared to other fields, this does not explain greater RPE responses in findings. It is therefore suggested, small field size resulted in increased technical actions and activity in general locomotion, increasing energy costs and workloads demands, resulting in increased player perceived RPE responses compared to medium and large fields. The study found significant greater performance of increased technical actions involving shooting, dribbling, passing and tackling, as a consequence to closer proximity of players in response to prescribed small field size.

It is further suggested RPE responses are mediated not only within physiological factors but also psychological factors resulting in variability within individual player responses (Borg et al., 1987: Morgan 1994), resulting within difficulty and limitations to draw true conclusions of RPE findings.

Manipulation of SSGs field size playing area has been investigated in previous research studies (Little et al., 2006), however prescribed SSGs design and confounding effects on variables in relation to field size, work rate intensity of
players, game duration, rest ratio, ability level of players, player age and all differentiate, making true comparisons difficult to previous researched literature.

2.6.2 Player numbers adult

Impellizzeri *et al.*, (2006) found players participating in smaller player numbered SSGs teams produce greater values within heart rate responses. Whilst Katis et al., (2009) found lower player numbers to be more beneficial for providing better stimulus to enhance technical skills, through increased technical actions in response to larger player numbers.

Furthermore, Rampinini *et al*, (2007) realised 3v3, 4v4 and 6v6 SSGs can effectively provide technical and physical demands of competitive game play, placing high demands on cardiovascular system, whilst developing VO₂ levels. In general current studies continue to demonstrate small player numbers stimulate an increase in physical, perceptual, time and motion responses through increased distance covered (Katis et al., 2009).However, previous studies found different conclusions, and claim no differences were found in heart rate values involving larger player numbers compared to small (Hoff *et al.,* 2002; Jones et al.,2007).It was further shown greater RPE scores were recorded in SSGs with fewer player numbers than those with larger numbers ,(Aroso et al.,2004; Hill-Haas et al.,2008,2009;Impellizzeri et al.,2006:Rampinini .,2007).

The variation within findings in SSGs research relevant to player number influence can be based on cause effects of authors adopting varied study populations, varied protocols and SSGs formats, leading to various physiological and time motion responses from players.

2.6.3 Game duration intermittent or long periods of play adult

SSGs formats are traditionally played in continuous or short intermittent periods of play. Time and motion characteristics and physiological responses were compared in continuous and short intermittent formats, it was found players covered more distance and greater sprints total in short intermittent SSGs formats (Fanchini *et al.*, 2011).Significant increased heart rate responses were reported in SSGs intermittent intervals of 6 and 4 minute game formats compared to 2 minute intervals. Results indicated intermittent applied bouts of 6 minute SSGs format of play, achieved greater maximum heart rate percentage, compared to shorter 4 and 2 minute intermittent games. The findings show 4 and 2 minute SSGs of short intermittent play formats compared to 6 minute provided less game time duration and a cause effect of less playing time for players to increase workload demands to generate physical responses, combined with frequent periods of rest.

It was further shown,10 minute continuous game formats were found to produce higher intensity workloads compared to shorter intermittent interval SSGs formats, however ,it is possible players may apply a pacing effect, during intermittent applied bouts resulting within less application of intensity of workload. Soccer players within a game duration in order to combat and endure physical workload will reduce game workload tempo (Carling et al., 2010).The face validity of Fanchini et al, (2011) study, appears convincing with reliable confounding effects to allow measurement and collection of data on physiological responses in intended youth player population. Findings correlate with content validity and findings from previous studies (Hill-Hass., et al 2009) which have been found to be valid and reliable.

2.7 Youth player small sided game demands

2.7.1 Field size youth

Owen (2004) reported findings which are consistent and are in accordance with findings for adult players in SSGs studies , finding as field size became larger in 1v1s,2v2s,3v3s,4v4s,5v5s elite professional youth players mean heart rates increased compared to small and medium size fields, this demonstrates through enlarging playing field size, player heart rates can be elevated. Owen (2004) further found increasing player numbers in SSGs decreased heart rate. Owen (2004) study suggests coaches can manipulate exercise intensity in SSGs to develop and promote player physiological parameters. However an applied 12 minute rest ratio between SSGs bouts involving increased player numbers may further have added to players significant findings of decreased heart rates , further offering an explanation for decreased heart rate findings.

Casamichana et al., (2010) provided a good depth of evidence for findings reached within their study. A cause effect of field size, player numbers, game rules, and coach encouragement was responsible for significant results found in player heart rate, RPE, time motion and technical skill requirements. SSGs large field increased heart rate values opposed to small and medium fields. It was further found, the effect of field size on a player's rate of perceived player exertion (RPE) within large field received greater RPE ratings in comparison to medium and small field. Furthermore it was found, small field created greater increased significant actions in technical skills of ball control, shooting, dribbling and tackling due to closer

proximity of players. Previous studies have found general locomotion of dribbling, significantly increases energy costs (Reilly et al., 1984).

Casamichana et al., (2010) face validity appears appropriate and is similar in nature with previous assessments applied in other studies which have been shown to be valid and reliable for measurements (Araso 2004; Owen et al, 2004).Construct validity of data and measurements correlate and are in accordance with similar research result findings (Araso 2004; Owen et al, 2004;Katis et al.,2009).It is therefore suggested Casamichana et al., (2010) study provides valid research and objectives, and seems convincing in providing a good degree of internal and external validity, relevant to selection, testing ,measurement and study population sample size and findings. To date no study has proven for definite that either small or large field size has more significant influence on player's physical intensity in SSGs (Aguiar *et al.,* 2012).

Study	SSGs	Field Size	Time	Heart Rate	Distance Covered (m)
Casamichana et al. (2010)	5v5	32x23m	8 min	86.0 HRmean	695 m
	5v5	50 x35 m	8 min	88.5 HRmean	908.m
	5v5	62 x44 m	8 min	89.9 HRmean	999 m
Hill-Haas et al. (2010)	3v4	37x 28m	24 min	83.3%HRmax	2,439 m
	3vs3+1	37X 28m	24 min	84.8%HRmax	2,405 m
	5v6	47 x35 m	24 min	81 %HRmax	2,471m
	5v5+1	47 x35 m	24 min	83%HRmax	2,583 m
Katis & Kellis (2009)	3v3	15 x25 m	10 x 4min	87%HRmax	
	6 v 6	40 x30 m	10 x 4min	82%HRmax	
Rampinini 2003			4x4min	88%HRMax	
Araso 2004	3v3	30x20m	3 x 4 min	87%HRMax	
	4v4	30x20m	3 x 4 min	70%HRMax	
Reilly 1998		30x20	3x1.30min	84%HRMax	
Reily 2004	5v5		6x4min	85-90%HRMax	

Table 4: Youth player studies within small sided game formats

Owen et al, (2004)	1v1	5x10m	3min	86% HRMax
	1v1	10x15	3min	88% HRMax
	1v1	15x20m	3min	88% HRMax
	2v2	10x15	3min	84%HRMax
	2v2	15x20m	3min	87%HRMax
	2v2	20x25m	3min	88% HRMax
	3v3	15x20m	3min	81% HRMax
	3v3	20x25m	3min	81% HRMax
	3v3	25x30m	3min	84%HRMax
	4v4	20x25m	3min	72%HRMax
	4v4	25x30m	3min	78%HRMax
	4v4	30x35m	3min	77%HRMax
	5v5	25x30m	3min	75%HRMax
	5v5	30x35m	3min	79%HRMax
	5v5	35x40m	3min	80%HRMax

2.7.2 Player numbers youth

Similar to adult SSGs studies it is common for coaches to apply formats of SSGs involving different varied numbers of youth players to elicit different time motion and physiological responses, (Hill-Haas et al., 2010; Sampaio et al., 2007; Owen et al., 2004).As in accordance with adult studies, youth SSGs studies show formats containing fewer players elicited higher heart rate values than larger numbered SSGs formats (Hill-Haas et al., 2010; Owen et al., 2004).

However, studies have reported finding no differences in heart rate responses within comparisons of player numbers in SSGs (Aroso *et al.*, 2004;Jones et al.,2007;Hoff et al.,2002).Hill-Hass et.,(2002) found variability between SSGs had a typical error below 5% across varied SSGs results.

It is common in SSGs to apply one team with a numerical advantage, with purpose to influence player technical skills through increased ball contact and challenge tactical awareness and physical responses as shown within Owen *et al.*, (2004) who found aerobic output increased and greater heart rate responses were achieved within teams with less player numbers. In accordance with the adult game findings, it was shown youth soccer players within 3v3s SSGs, performed more

technical skills of dribbling, shooting and passing in comparison to 5v5s SSGs, (Platt et al.,2001). It was further shown when increasing youth player numbers in SSGs caused a total increase within number of technical actions, however total number of individual technical actions decrease per player (Owen,2004). Aroso *et al.,* (2004) further found 3v3 in comparison to larger player numbers of 7v7 provided greater RPE responses.

2.8 Global positioning system (GPS) time and motion

Global positioning system (GPS) is originally a satellite navigational tool developed for military use, group or individual movement can be tracked, three dimensionally over a period of time on land, air, or water environments. Portable GPS unit development has allowed for this technology to become wider used, such as expansion into sports, allowing for a means of understanding and describing physical activity and its spatial context. GPS technology devices are manufactured with different sampling, in which device units vary in speed of information gathered, the GPS units come in 1-5 or 10-Hz sampling rates frequency signals (Pyne, et al., 2010).

Previous studies suggest higher frequency GPS units provide distance measurements which are more valid and give greater precision (Jennings et al.,2010). Therefore, higher sample rates per second, results within more accuracy of the original waveform (Hargrave, 2001), signals samples within a 10Hz unit are recorded every 0.1 seconds, over a one minute period this creates 600 samples, making it a more accurate GPS unit, in comparison to a 5Hz unit which records

every 0.2 seconds, over a one minute period creating 300 samples or a 1Hz unit which records every 1 second over a one minute period creating 60 samples.

GPS units with higher increased frequency demonstrate improved validity and reliability and are widely applied within professional soccer for physical activity monitoring.

GPS was used for the first time in 1974, for tracking athletes (Schutz et al., 1997) and is now used regularly within sports by sports scientist, trainers, and coaches to provide performance analysis during training and competition.

GPS is used extensively in soccer, cricket, hockey, rugby union, rugby league and Australian football league. GPS athlete profiling in literature provides numerous amounts of information, on measurement of athlete movements, quantifying of exertion levels and physical stress on athletes , performance in competition , assessment of training workloads and training physiological demands (McLellan, et al.,2011),such as patterns of athlete movement (external loads), physiological responses (internal loads).

GPS in sports is used regularly to measure components of athlete movement, as distance and speed travelled, movement patterns, amount of accelerations and decelerations, triaxial accelerometer was integrated into the GPS system to allow the capture of physical loads and patterns of work rate.

The sum measurements of accelerations is recorded within X,Y,Z planes and within three axes (Waldron et al.,20011).Speed analysis and its characteristics in GPS technology is classified into six bands of activity, the bands are named speed and impact zones. The lowest level indicates Zone one, while highest level indicates Zone Six, which represents top effort or impact (McLellan et al.,2011).Player or athlete performance can be analysed and compared within games and training.

Literature suggests GPS units are reliable and demonstrate acceptable validity within assessment of physiological increased workloads and movement over distance involving speed, allowing for utilization of GPS application in relation to player profiling, investigating physiological workloads, player injury risk and fatigue. As validated and applied within previous studies (Dellal *et al.*,2011; Casamichana et al.,2010).

With new advancements in technological approaches within soccer analysis, such as global positioning systems (GPS) now readily available, GPS in soccer analysis is now a primary tool in examining physiological and physical demands in training and games. Within GPS soccer studies, player external work rate demands are expressed in training and game activities as total distance covered in various categories of standing,walking,jogging, running, sprinting (Reilly et al.,1976;Buchheit, et al.,2010).

This allows for recognition of time spent within patterns of exercise categories, which can be broken up in training and game performance into workload frequencies and durations, allowing for examination in greater details of player work rate loads, recognising deterioration in workload performance and indications of the player encountering fatigue.

Global Positioning System (GPS) advances in soccer have enabled more understanding of demands of training and adaptations of soccer (Little, 2009). GPS can now allow for accurate measurements of player profiling for time and motion loads in soccer activities. GPS technology permits within team sports, scope to allow player movement measurement in training or game situations, recognising and measuring movement patterns, speeds and position of players. GPS can aid in

enhancing training programmes to optimizing athlete preparation for competitive performance and training.

However, within worldwide competitive professional soccer competition, national soccer federations do not permit use of Global Positioning Systems in professional competitive games, which attributes to limited research findings on GPS in professional soccer. However, GPS technology is used regularly by many top professional clubs worldwide in professional soccer training environments, to enable measurement of player workload movement over varied distance and speeds.

Within a soccer training environment, GPS technology is very beneficial, providing instant real time information on movement demands such as distance covered and speed to coaches and sports science support staff. GPS units are worn within a vest which is tight fitting and held in-between players shoulder blade area in a custom-made tight-fitting vest (Harley et al.,2010), the unit receives signals sent from three satellites (Barbero-Alvarez et al.,2009) ,which allows the GPS unit to gather information to record and calculate data on players position, time and velocity (Edgecomb et al,2006),relative to total distance covered, time spent in identified zones and changes in player velocity (Barbero-Alvarez.,et al,2009), recognising intensities obtained, furthermore GPS simultaneously monitors and records player heart rate (HR) whilst measuring player movement patterns (Carling et al.,2008).

Therefore this function allows for identifications in physiological responses, indicating between player intensity of work rate loads, furthermore it allows for preventative intervention method of recognising overtraining in workloads and further allows for estimations in players maximal oxygen uptake and expenditure of energy (Achten et al.,2003;Rudolf et al.,2009).

Concerns with GPS unit signal failure can occur if the signal is lost from satellites occurring, resulting within compromising of integrity of data. GPS units are designed for outdoor use, and less reliable for usage indoor, however units have indoor modes to monitor heart rates and an accelerometer. GPS unit may lose power due to usage demand, resulting within low battery life, with battery life running up to 4-6 hours. Undertaking a number of training sessions per day could become problematic due to time limitation of battery life and access to available time to allow the opportunity to recharge the units for next session.

GPS Validated Research	System	Sample Frequency (Hz)	Heart Rate	Accelerometer	Real Time
Peterson et al,2009	Catapult Minimax X v.2.0	1&5 (Hz)	Yes	Yes	Yes
Duffield et al, 2010	Catapult Minimax X v.2.0	1&5 (Hz)	Yes	Yes	Yes
Jennings et al,2010	Catapult Minimax X v.2.0	1&5 (Hz)	Yes	Yes	Yes
Portas et al, 2010	Catapult Minimax X v.2.0	1&5 (Hz)	Yes	Yes	Yes
Castellano et al,2010	Catapult Minimax X v.2.5	10 (Hz)	Yes	Yes	Yes
Peterson et al,2009	GPSports SPI Pro X II	15 (Hz)	Yes	Yes	Yes
Peterson et al,2009	GPSports SPI Pro	5 (Hz)	Yes	No	Yes
Barbero-Alverez et al.,2010 Coutts et al.,2010 Duffield et al, 2010 Grey et al.,2010 Macleod et al.,2010	GPSports SPI Elite	1 (Hz)	No	No	No

Table 5: Shows multiple research studies which validated the reliability of various GPS systems

GPS units according to Catapult (2009) are a reliable source for measurements with margin for error being minimum. Catapult (2009) showed 10Hz units used for sprinting in a straight line for 20 metres incurred 2% (40cm) inaccuracy and 4% (40 cm) sprinting longer distance over 40metres. Research evidence within studies have shown trust within validity of 10 Hz and 15 Hz GPS devices providing greater frequent sampling rate and increase reliability in accuracy of data they provided within measurements of acceleration, deceleration, velocity and distance (Castellano, et al., 2011; Varley et al., 2012).

Furthermore GPS 1 (Hz) and 5 (Hz) units have been found to be accurate for use within assessment of distance covered within linear motion during soccer Jennings et al., 2010; MacLeod et al., 2009;Portas et al.,2010) as in accordance with findings in similar studies (Coutts et al.,2010;Duffield etal., 2010). However short duration sprints involving changes of direction are found to be more inaccurate in 1 Hz and 5 Hz units measurements, with an error rate of 11.5 ± 3.0 meters (Jennings et al (2010),changes of running direction have been shown to increase error in GPS systems (Aughey, 2011).Results suggest quick short sprints in a number of directions show degrees of inaccuracy in GPS units. More accuracy and trust is shown within GPS systems which are known to provide greater sampling frequencies which allow increased accurate measurements of distance of greater velocities over longer periods of time (Aughey et al.,2010).It was shown from a standing start sprint over 10 metres, using a GPS unit of 1 (Hz), standard error of estimate was 32% and 30% for 5 (Hz) (Jennings et al., 2010). When sprint length was doubled to 30 metres sprints from 15 metres, standard error was reduced to 5%.

However, validity of GPS 5 (Hz) systems were raised when measuring real time match performance within Australian rules football (Aughey et al, 2010), found real

time data was shown to be significantly different to data downloaded from the GPS units post-game involving overall distance within every speed zone, the discrepancy was blamed on transmission loss and bandwidth for real time unable to transmit data. Highlighting caution should be applied when monitoring live play in real time and within evaluating post session data. Overall, GPS research concludes GPS devices demonstrate levels of acceptable validity and reliability within assessment of movement patterns at speeds which are lower and of increased distance. However GPS unit's reliability and accuracy decreases within ability to measure short duration movement patterns of high speed, straight line running, turning and rapid changing of direction. However, greater trust is shown in 10 Hz and 15 Hz GPS devices within providing greater reliability and validity within accuracy of measurements.

2.8.2 Speed zones adult and youth

Clearly within training and game GPS analysis of both adult and youth soccer players, applying same speed zones or thresholds is not appropriate or ideal, little information exists in research studies on this issue and associated challenges it brings in conducting GPS analysis in youth players, resulting in existence of uncertainty in application of zone thresholds in soccer research studies on youth players. The use of GPS in various age groups in elite youth soccer players through to adult players, require appropriate age categories for younger youth players, as reduced speed zones allow accurate account of athletic abilities.

Elite youth soccer player competitive game play and training performance in SSGs and conditioned games has rarely been investigated , information relative to

determining speed thresholds ,distance covered, repeated high intensity sprints of elite youth soccer players could provide clubs and support staff information of value in regards to player development ,injury prevention, and game related situations.

Applying adult player speed thresholds to youth players is inappropriate, previous research reports sprinting performance of elite youth players has a positive relationship to player's age (Mujika et al ,2009). Having an understanding of demands placed on youth players in SSGs can allow for clearer prescription processes in applying the training process, quantification of training loads and in identifying talent elite youth players. It was suggested in previous research Bradley et al,(2009),sprint speed zones for elite youth players should be specific to age groups. Within measurement of physical performance characteristics of elite youth players, the various youth age group levels should be taken into consideration, and normalised to age group speed threshold capabilities, through assessment of 10 metre flying sprint times. Within soccer, analysis of categories of codes for player movements and thresholds of speeds is still not agreed. Research literature available demonstrates little discussion in selection criteria for activities of game movement patterns relative to analysis of youth player movement activities. Patterns of activity thresholds in speeds (speed zones) in youth players must be determined, in game analysis, as current literature demonstrates no consensus or agreement on application of correct speed zones to be applied, previous youth player research studies have adopted numerous speed zones from previous youth game analysis literature.

Speed zone classifications of GPS are designed and defined for adult soccer players, which may be unsuitable for true reflection of younger youth players training speed demands, as younger youth players will display metabolic differences in exercise relative to biomechanical movements and physiological workloads relative

to speed zones. In comparison to adult players, it has been recognised (Ebbeling et al.,1992) younger adolescents during aerobic exercise display energy levels which are lower in submaximal and maximal exercise; due metabolic differences and increased workload of locomotion, running speed engaged in, forces higher percentage of workloads in maximal aerobic capacity .Few research studies attempt to determine speed thresholds for application in youth soccer players, recognising speed variation in exercise of high intensity of youth players is important, the process of categorizing speed thresholds and distinguishes differences in player speed allows analysis of sprint performance in various youth player age groups (Carling, ,Le Gall et al.,2012). Gastin et al, (2013; 2014) applied absolute speed thresholds to determine intensity in running performance of u11 to u19 youth players in games, this method was deemed inappropriate due to variations in performance capacities between youth and senior mature players (Harley et al, 2010), therefore any association found in Gastin et al. (2013, 2014) between game running performance and younger youth mature player may not be accurate, as applying absolute threshold speed favours older mature players. Running speed thresholds are based, structured for speed that knowingly improves in players maturation and growth (Mendez-Villanueva et al,2011: Papaiakovou,2009)

Harley et al, (2010) determined speed thresholds in elite youth players through testing youth players relative peak velocity against senior adult players relative peak velocity in a 'flying' 10-m sprint, individual mean velocity values from different age groups were calculated and a mean ratio applied to use as a mean youth speed threshold to allow relative age group speed zones be applied (Harley et al., 2010).Optimal levels of speed performance in elite youth soccer players in various age groups may be determined, allowing youth players speed capabilities to be

recognised. As commonly applied and validated in previous studies, appropriate speed thresholds zones for relevant youth age groups were calculated and used in this study (table 6), through testing all elite youth player age groups for flying 10 metres sprint times to allow calculation of peak velocity performance speed zones ,as applied in Harley et al, 2010,Goto et al.,2013.

However, limitations exists in Harley et al, (2010),Goto et al ,(2013) applied methodology in threshold bands , not accounting for individual degree of error variation in youth age group speed capacity when individualising threshold bands relative to peak velocity (vpeak) , this may be influenced through youth age group player maturation status in running mechanics and aerobic capacity. Previous research upon elite youth soccer players have applied many different game analysis methods and techniques, different running speed threshold ranges and used varied sample population sizes, this result in an inability to precisely and accurately evaluate and compare differences in findings between studies.

Speed	10 m Split	< 1	<2	<3	<4	<5	6
Zone	time	Standing	Walking	Jogging	Running	High	Sprinting
(<m -1)<="" s="" td="" ⋅=""><td>(mean)</td><td></td><td></td><td></td><td></td><td>Speed</td><td></td></m>	(mean)					Speed	
						Running	
u/20 _{Senior}	1.15	<0.50	<2.00	<4.00	<5.50	<7.00	>7.00
u/17/16	1.24	0.48	1.93	3.87	5.32	6.77	6.77
u/15	1.33	0.45	1.8	3.61	4.96	6.31	6.31
u/14	1.43	0.42	1.67	3.35	4.61	5.87	5.87
u/13	1.45	0.41	1.65	3.31	4.55	5.79	5.79
u/12	1.48	0.40	1.62	3.24	4.45	5.67	5.67
u/11	.1.56	0.38	1.54	3.07	4.23	5.38	5.38

Table 6:	Player	speed	zones
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(Flying 10 m Senior / Flying 10m Age Group) x Threshold Speed (Harley 2010)

The use in training sessions of GPS, aims to present individuals physical development for demands in team sports, aiming to maximise training loads of sustainability in training or competitive performance, further aiming to prevent the

risk of injury, allowing for marked physical increases in individual to encounter and combat workloads (Gabbett, et al., 2007). It was recognised Piggott et al., (2009), athletes overloading in training loads, demonstrated spikes in recorded data relative to overload workloads , resulted in an injury to athletes, thus an athlete's optimal training volume and intensity, should not be allowed to exceed, tolerance capability during exercise. It was further found (Gabbett, 2010) when players in rugby league, significantly exceeded their training threshold, they were at higher risk of injuries to soft muscle tissue. Thus it is recognised GPS technology can be used in regulation of athlete training loads and to inform of potential injury through overtraining in sessions and throughout competitive season for both youth and adult players. Improvements in GPS technology have now allowed comparisons levels between training and competition loads relative to work rate in speed zones, speed, distance covered, patterns of distance. GPS technology has further enabled detection of possible injury to athletes, through monitoring loads in training, and recognising when training loads are have caused overtraining and fatigue, or determine when to optimize a players return from injury to competitive match play and training.GPS use in live analysis allows player load feedback which is instantaneous to sport science support team or coaches, relative to patterns in rate of workloads, further allowing monitoring of fatigue, rotation and adjustments of players in training performance and competition.

The utilization of GPS technology now enables a facility to collect and measure physical demands placed on athletes in a training and competitive environment. However, for future research, standardizing youth players observed movement pattern activity, typically performed in soccer must be a focus, to allow selection criteria to be standardized and acknowledged and potentially applied in future

research literature. No gold standard exists in GPS, due to the lack of uniformity in standardization and classification limits of speed zones, description of comparisons within movement demands in team sports (Randers et al, 2010). Inconsistencies in criteria for GPS movement, external output and physical demand fails to facilitate a universal gold standard to aid within comparisons of player performance.

3.0 Methods

3.1 Introduction

The research study was conducted from November 2014 to June 2015 period, in the 2014–2015 competitive season. The study was of a good sample size, 96 players were selected through the clubs head of youth academy to participate in study. Players participated in three bouts of three minute SSGs of 4v4s with 1.30 seconds rest between games, within small (20x20m), and large (40x40m) fields.

All participation within the study was voluntary, with participants free from injury. Player's in-season skill and physical level was at peak condition. All players were elite youth soccer players, training within the football academy for the past six months. The player's training schedule, involved daily specific soccer training sessions lasting sixty to ninety minutes, three times per week, involving one competitive game a week, with two days off for rest and recovery. No player was allowed to participate in study the day before and two days after competitive games. All practical research was performed in evening training session between 6.00pm to 8.00pm, as part of the player's normal training timetable. Participating players were informed of aims of SSGs structure in regard to encourage players' full effort. Players were placed in own age levels to help combat maturational age bias of chronological individual difference, and control factors in individual player limitations to allow accurate judgement, players were grouped in their specific youth age level, to allow similar cause effect relationship between time/motion, physical and technical comparisons.

3.2 Participant Information

This study used ninety six elite youth soccer players from a Professional League First Division Football Club. Consent was granted to attend the Youth Academy of Football to carry out research. Participant players were recruited from U/11 to U/17 squads by head of youth .All participating players were between the age of 11 years to 17 years of age. This study was approved by the Research Ethics Committee of Edinburgh Napier University. The participants were fully informed in relation with procedures to be applied and the experimental risk. Written informed consent was obtained from all u11/u12/13/u14/u15/u16 youth players, and parents or guardians.

3.3 Equipment

3.3.1 Heart Rate Monitor

Heart rates were measured and stored through the use of Polar S810 HR monitors (Polar Electro OY, Kempele, Finland).

3.3.2 Height

Player height was measured using a stadiometer ,(SECA, Hamburg, Germany),

3.3.3 Body Weight

Electronic scales (SECA) to measure body mass. (SECA, Hamburg, Germany),

3.3.4 Global positional system (GPS)

Global positional system (GPS) measurement of player physiological workloads was assessed through data results from players wearing a 10-Hz GPS ,triaxial accelerometer (MiniMaxX, Catapult Innovations, Melbourne ,Australia), as validated within other studies (Casamichana *et al.*, 2010).

3.3.5 RPE Scale

Players rate perceived exertion was assessed through using the Borg (20)6-20 point scale. Studies within literature validated this method of measurement of perceived exertion giving a valid indication of exercise intensity (Chen, 2002).

3.4 Protocol

3.4.1Baseline procedures Experimental trials

In a four week time frame prior to the start of SSGs protocols, Physiological profiling of players was carried out, this involved measurement of aerobic, and anaerobic capacities, speed, power and strength measurements, heart rate, age, height, weight, flexibility testing each players maximal heart rate and estimated $\dot{V}O_2$ levels was established, this involved field testing which demands incremental maximum heart rate, the test to be applied was the Yo-Yo intermittent recovery test to allow for prediction of $\dot{V}O_2$ levels and also maximum heart rate (HR_{max}) (Bangsbo et al.,2008).

3.4.2 Experimental trials

Player maximum heart rate (HRmax) was established, this involved field testing which demands incremental maximum heart rate, the test applied was the Yo-Yo intermittent recovery test, this corresponds to player distance covered to allow for prediction of player \dot{VO}_2 levels after establishing players total distance covered in test (Bangsbo et al.,2008).Level 1 \dot{VO}_2 max = distance in meters x 0.0136 + 45.3,Level 2 \dot{VO}_2 max = distance in meters x 0.0084 + 36.4 (Bangsbo et al.,2008).

The Yo-Yo recovery test consisted of players running 20-metre shuttle runs repeated twice, running back and forward between the start, turning, and finish line, progressively increasing speed, controlled through audio bleeps via compact disc player. The test was conducted on a 3G astroturf grass synthetic field, within small groups as proposed Bangsbo et al.,(2008).

Performance of physical testing was carried out in the evening team training sessions between 6-00pm and 7.00pm indoors, further it was not known what other activity had been conducted during the day from subjects and levels of fatigue encountered or injury status. A battery of physical tests was designed to allow youth team players to perform testing over an allocated one hour time period, which limited type and number of test administered due to time constraint placed on availability of players. Each youth team squad were tested on one occasion, no post physical testing was carried out to allow comparison of test results, due to timetable constraints within competitive league programme and training schedule.

No different changes were made in experiment conditions in SSGs format or research design, with all youth age groups conducting SSGs experiment during their normal evening training session between times 6.00-8.00pm outdoors. Players were

grouped with own youth age group with similar physical and technical abilities to help control chronological age bias in maturational individual difference. Every attempt was made to ensure this research project design, testing and measurement experiments had credibility, to allow the project to be considered valid through reliable applied methodology and procedures. Every player was allocated their own number coded GPS unit and heart rate belt, to allow performance measurement and recording of results ,allowing analysis of detection of differences between small and large field size effects on youth age groups.

3.4.3 Dependant measures

GPS variables of total distance covered (metres), maximum velocity and metres per minute, heart rate and RPE data within SSGs were collected from sixteen elite youth players per youth squad from u11 to u17 over twelve training sessions in a twelve week period. Players participated in three bouts of three minute SSGs of 4v4s with 1.30 seconds rest between games, in small (20x20m), and large (40x40m) field.GPS 10Hz frequency units provided higher frequency and more accuracy of valid measurements with greater precision, with higher sample rates per second. GPS 10Hz unit signal samples recorded every 0.1 second, creating 600 samples in one minute, as found and in accordance with previous studies (Jennings et al.,2010).Sample rates were taken with focus on one field size per age group training night, over two separate training nights for each youth age group. No goalkeepers were used and normal eleven - aside soccer rules were used, with exception of offside rule. Extra supply of soccer balls were placed around boundaries of field areas and in goals, to allow re-starts immediately after ball going out of play. Verbal

encouragement was allowed from coaches throughout games.SSGs took place outdoors on an all-weather 3G synthetic grass pitch, following an eight minute dynamic warm up. Standard five a-side size goals were used (2 m wide x1.2 m high).

Global positional system (GPS) measurement of player physiological workloads was assessed through data results from players wearing a 10-Hz GPS ,triaxial accelerometer (MiniMaxX, Catapult Innovations, Melbourne ,Australia), as validated within other studies (Casamichana *et al.*, 2010).

Table 7: SSGs de	sign characteristics
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SSGs	Game	Rest	Field	Field total	Field ratio	Player	Coach
Design	Duration		Area	area	per player	Standard	Encouragement
-			(m)	(m2)	(m2)		-
4 v 4	3x3min	1.30	20x20	400	50	Profession	Yes
			(small)			al Youth	
4 v 4	3x3min	1.30	40x40	1600	200	Profession	Yes
			(large)			al Youth	

3.4.4 GPS analysis / measurement

Players wore a training bib harness which enabled a Catapult GPS monitoring device to be fixed to their upper back. This device was a 10-Hz Catapult GPS software (MiniMaxX, Catapult Innovations, Melbourne ,Australia) ,the minimax S4 accurately measured players performance in training and competition, giving readings for player loads such as total distance covered (metres),metres covered per minute, maximum velocity, accelerations ,decelerations, , repeated high intensity efforts, change in directions , jumps ,speed zones ,heart rate ,allowing for monitoring and comparison of physical capacity data points of players in training and games. Study zones of speeds were adapted to allow for categories to be recognised and for comparisons, as in others studies (Casamichana et al.,2010).Variables recorded in SSGs formats were, total distance covered (m), metres per minute, and maximum velocity.

3.4.5 Game measurements

Physiological workloads were measured and observed during SSGs 4v4 games, in order to allow physiological variables to be assessed without restriction. Both SSGs formats (20x20) (40x40) consisted of three bouts of 3x3min games with 1.30min rest. Assessment of Heart rate (HR) monitoring throughout SSGs on all players through the use of (Polar Team System, Kempele, Finland).GPS monitoring through Catapult GPS software , Catapult Innovations, Melbourne ,Australia.

3.4.6 Heart rate measurements

Within SSGs all mean and maximum heart rates were measured using Polar devices for HR monitoring. This has been validated in several studies (Goodie *et al.*, 2000; Kingsley *et al*) All players were instructed to regularly check monitors are functioning correctly. Mean and percentage of heart rate maximum (%HRmax), during physical performance testing and SSGs formats was calculated for each player .Rest periods between exercise drills were excluded from analysis. All testing heart rate data was downloaded at end of each session to a computer using (Polar Precision S-Series Software SW 3.0) and safely stored. This data informed and indicated players were encountering physiological stress and discomfort.

3.4.7 RPE Scale

Players rate perceived exertion was assessed through using the Borg (20)6-20 point scale. Studies within literature validated this method of measurement of perceived exertion giving a valid indication of exercise intensity (Chen, 2002). Players were

familiarized with the use of the Borg (20)6-20-point scale in theory and practical sessions prior to start of research and testing. Individual Participants RPE was recorded following completion of each final game. Each player was individually asked for their score, away from other players, to prevent influences from others.

3.5 Data analysis

Statistical data was analysed using statistical package for the social sciences (SPSS) software version 20. Statistical significance was set at p < 0.05, with all data expressed as means \pm standard deviations, to test for normality of distribution of data, a Shapiro-Wilk test was used. Factorial mixed design analyses of variance (ANOVA) were used to measure statistical significance between independent variable of youth age groups and dependent variable of field size in relation to SSGs time motion and physical responses. Omega squared was also calculated. One-way analyses of variance (ANOVA) were used to measure statistical significance within physical performance tests, with a Tukey post-hoc multiple comparisons analysis. Effect size of eta partial (η 2) and Post hoc test was used to identify effect size difference. Cohen's d effect size (ES) was calculated through mean of group 1 subtracted from mean of group 2, divided by standard deviation. ES classified as 0.2=small effect; 0.5= medium effect; 0.8= large effect.

4.0 Results

4.1 Participants

All players successfully completed protocols within 4v4 small sided games and produced physiological responses for RPE measurements.

	u/17/16	u/15	u/14	u/13	u/12	u/11
Age	16.2±0.5	14.5±02	13.4±02	12.4±0.2	11.4±.0.2	10.4±0.2
Height	179.1±4.7cm	172.8±6.6cm	160.3±9.6cm	151.9±7.8cm	144.7±6.1cm	142.4±5.8cm
Weight	69.5±6.5kg	60.7± 8.4kg	48.0± 7.5kg	41.9±6,6kg	36.1±4.4kg	33.6±4.2kg
10 metres	1.74±.064	1.80±.073	1.91±.073	1.97±.077	1.94±.054	1.99±.087
20 metres	3.01±.097	3.13±.127	3.32±.133	3.48±.168	3.41±.095	3.54±.119
505 Agility	2.22.±.066	2.27.±.049	2.34±.106	2.44.±.094	2.46.±.095	2.48.±.071
Yo-Yo test	1848±.375	1658±.317	1629±.401	1332±.389	1277±.276	1035±.275
^{VO} ₂ levels	53.1±2.83	45.6±.424	44.0±.377	41.1±4.73	39.2±.745	35.4±1.12
Max heart Rate	214±7.4	209±7.4	207±7.3	203±3.0	204±3.4	203±5.4
Sit& Reach	27.8±5.37	23.5±4.94	24.0±4.61	22.1±3.17	21.8±4.66	23.3±4.11
Squat Jump	46.5±5.77	43.0±4.81	40.0±4.37	35.3±4.18	35.5±5.66	34.7±5.19
Counter Jump	50.1±5.77	46.9±4.65	44.9±5.21	39.4±3.48	40.7 ±5.09	40.6±6.41

Table 8: Youth player characteristics and performance tests mean ± sd values

4.2 Physical performance test results

Ninety six (96) elite youth soccer players from a professional youth academy were tested and measured in standing height, body weight, flexibility sit and reach, 10-20 m sprint, 505 agility, squat jump, counter movement jump with arms, the Yo-Yo

intermittent recovery test (level 1) to allow estimated \dot{VO}_2 levels and maximum heart rate,(Bangsbo et al.,2008).It was found all variables measured within physical performance improved chronologically in all age groups. Batteries of reliable physical field tests were conducted to examine and establish physical performance characteristics in players. Physical performance results showed significant difference p <0.05 within sprint performance between u17/16 in comparison to all other age groups u/15/u/14/u13/u12/u11within following tests, 10 metre sprint (P<0.05), 20 metre sprint (P<0.05), 505 agility test (P<0.05) and Yo-Yo intermediate level 1 test (P<0.05).Furthermore u17/16 produced greater significant (P<0.05) difference in squat jump, counter movement jump (P<0.05) and sit & reach test (P<0.05) in comparison to u/15/u/14/u13/u12/u11.

U17/16s produced greater significant difference p < 0.05 within maximum heart rate (214.2±7.7bpm) and produced greater significant difference (P<0.05) within estimated $\dot{V}O_2$ levels (53.1±2.8 ml•kg-1 • min-1).compared to other youth age groups. It was found u11s scored greater test results in sit & reach (22. 9±4.2cm) in comparison to u/12 (21.5±3.8cm) and u13 (21.7±3.3cm),and likewise with u14s scoring greater sit & reach results (24.7± 3.6cm) in comparison to u15s (23.5±4.9cm).U12s scored greater test results in counter movement jump (40.4±5.0cm) in comparison to u/13s (39.4±3.4cm). It was further found U12s scored faster speed results (1.94±0.5sec) than u13 (1.97±0.7sec) in 10 meter sprint testing.

Countermovement jump performance test showed u17/16 produced greater significant difference (P<0.05) compared to all other youth age groups, Post hoc tests showed Cohens d effect size comparisons for youth age groups found small E.S 0.3, u17/16 vs u/15.and medium E.S 0.5 u17/16, u15 v u14; large E.S.1.0,

u17/16, u15 v u11, 12, 13; medium E.S 0.5 u14 v u11, 12, 13.Whilst small E.S. 0.1was found for u11, 12, 13.

Sit & Reach performance test showed u17/16 produced greater significant difference (P<0.05) compared to all other youth age groups. Post hoc tests showed Cohens d effect size comparisons for youth age groups found E.S 0.5, u17/16 vs u/15 and large E.S 0.7 u17/16 v u11, 12, 13, 14, small E.S. 0.2, u15 v u11,12, 13,14; small E.S 0.2 u14 v u11,12,13. Whilst small E.S. 0.1 was found for u11, 12, 13.

Squat Jump performance test showed u17/16 produced greater significant difference (P<0.05) compared to all other youth age groups. Post hoc tests showed Cohens d effect size comparisons for youth age groups found small E.S 0.4, u17/16 vs u/15 and medium E.S.0.5 u17/16 v u14; large E.S 1.1 U17/16, u15 v u11, 12, 13; medium E.S. 0.5, u14 v u11, 12, 13.Whilst small E.S. 0.1 was found for u11, 12, 13.



Figure 1: Displays youth age groups sprint times. Bar heights are mean values and error bars are 95% CI values. Data was analysed with ANOVA followed with Tukey post hoc tests.

Statistical analysis found significant difference (P<0.05) between groups and within effect size in sprint performance in 10 m, (F (2, 94) = 33.0, P = <.001, partial $\dot{\eta}^2$ =.63), U17/16 produced greater significant difference (P<0.05) compared to all other youth age groups. Post hoc effect size follow up test of Cohens d effect size was conducted for comparisons in youth age groups, 10 metre sprint test performance found small E.S 0.2, u17/16 vs u/15.and medium E.S 0.6 u17/16, u15 v u14; large E.S.0.9, u17/16, u15 v u11, 12, 13; small E.S 0.3 u14 v u11, 12, 13.Whilst small E.S. 0.2 was found for u11, 12, 13, between age group comparisons.

Statistical analysis found significant difference (P<0.05), between youth age groups within sprint performance in 20 m, (F (2, 94) = 48.6, P = <.001, partial $\dot{\eta}^2 =.71$), U17/16 produced greater significant difference (P<0.05) compared to all other youth age groups. Post hoc effect size follow up test of Cohens d effect size was conducted for comparisons in youth age groups, 20 metre sprint test performance found small E.S 0.2, u17/16 vs u/15 and large E.S 0.7 u17/16 v u14; large E.S. 1.1, u17/16, u15 v u11, 12, 13; small E.S 0.4 u15 v u14, medium E.S. 0.5 u14 v u11, 12, 13. Whilst small E.S. 0.2 was found for u11, 12, 13, between age group comparisons.

Statistical analysis found significant difference (P<0.05), between youth age groups within sprint performance in 505 agility test (F (2, 94) = 31.6, P= <.001, partial $\dot{\eta}^2$ =.62), U17/16 produced greater significant difference (P<0.05) compared to all other youth age groups. Post hoc effect size follow up test of Cohens d effect size was conducted for comparisons in youth age groups, 505 sprint test performance found small E.S 0.3, u17/16 vs u/15 and large E.S 1.1 u17/16, u15 v u11, 12, 13, 14;

medium E.S. 0.5, u15 v u14; large E.S 0.8 u14 v u11, 12, 13. Whilst small E.S. 0.1 was found for u11, 12, 13, between age group comparisons. Mean \pm SD comparisons are indicated in table 8.



Figure 2: Displays youth age groups mean (metres) Yo-Yo test results. Bar heights are mean values and error bars are 95% CI values. Data was analysed with ANOVA followed with Tukey post hoc tests.

Statistical analysis found significant difference (P<0.05), between groups and effect size (F (2, 94) = 13.8, P = <.001, partial $\dot{\eta}^2 =.42$), within distance covered (metres) Yo-Yo test performance within u17+16s compared to other youth age groups. Post hoc test showed Cohens d effect size comparisons for Yo-Yo test performance found small E.S 0.2, u17/16 vs u/15/u14.and large E.S 1.0, u17/16, u15, u14 vs u11, 12, 13.Whilst small E.S 0.3 was found for u11, 12, 13, between group comparisons. Mean ± SD comparisons are indicated in table 8.



Figure 3: Displays youth age groups mean estimated $\dot{V}O_2$ level results. Bar heights are mean values and error bars are 95% Cl values. Data was analysed with ANOVA followed by Tukey post hoc tests.

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Statistical analysis found significant difference (P<0.05), between groups and effect size (F (2, 94) = 154.6, P = <.001, partial $\dot{\eta}^2 =.89$) in estimated $\dot{V}O_2$ levels within u17+16s compared to other youth age groups. Post hoc test showed Cohens d effect size comparisons for $\dot{V}O_2$ levels estimated performance show large E.S 3.3, u17/16 vs u/15,u/14, and large E.S 8.1, u17/16, u15,u/14 vs u11, 12, 13.Whilst large E.S 1.5 was found for u11, 12, 13 between group comparisons. Mean ± SD comparisons are indicated in table 8.



Figure 4: Displays youth age groups mean physical performance test results. Bar heights are mean values, error bars are 95% CI values. Data was analysed with ANOVA and with Tukey post hoc tests.

Statistical analysis found significant difference (P<0.05), between groups and effect size within u17, 16 compared to other youth age groups in performance testing. Squat jump, (F (2,94) = 18.9, p = <.001, partial $\dot{\eta}^2 = .49$); Flexibility Sit & Reach (F (2,94) = 5.8, P = <.001, partial $\dot{\eta}^2 = .23$); Counter movement jump (F (2,94) = 16.2, p = <.001, partial $\dot{\eta}^2 = .46$).

4.3 Small sided games GPS time and motion results

Data normality distribution was checked with Shapiro Wilk and Levene's tests, neither was violated and showed acceptable variability to run parametric test. Factorial Mixed Design analysis of variance (ANOVA) results showed significant differences within youth age groups time motion performance and field size results reported as total distance covered in metres, maximum velocity, and metres covered per minute. Velocity thresholds bands for age groups were applied relative to Harley, (2010).

4.3.1 Distance covered

Main effect youth age groups in SSGs performance

Statistical analysis investigating age group effect for distance covered revealed a statistically significant main effect for youth age groups, F=2972.5, P.001, w^2 =1.91, the main effect showed youth age groups significantly increased mean values scores across each different youth age group, with different mean values for each youth age group. Youth age groups showed significant difference (P<0.05) within SSGs large field performance for distance covered in comparison to small field, achieving greater total distance covered (metres), large field (mean \pm SD 1166 \pm 9.5), than small field (mean \pm SD.988 \pm 17.7). The u/17,16s,/15s age groups covered more total distance in SSGs large field 1166m and 1076m in comparison to u/11s,12s.13s,14s, small and large fields.

Main effect SSGs field size on age groups

Statistical analysis investigating distance covered revealed a statistically significant main effect for field size ,F=7977.4, P = <0.01,w²=2.13, the main effect showed youth age groups mean values were significantly higher in large field size compared to small field size. All age groups significantly (P<0.05) achieved greater total distance covered (metres), large field mean (± SD 1166±9.5), than small field (±SD.988±17.7). The u/17,16s,/15s age groups covered more total distance in SSGs large field 1166m and 1076m in comparison to u/11s,12s.13s,14s, small and large fields. Data demonstrates field size affected distance covered from all youth age groups. Findings' showing it is different for youth age groups running performance within accumulation of increased total distance covered, on large field in comparison to small field.

Interaction effect field size and youth age groups

Field size and Youth age groups revealed an interaction effect , F(2-94)=15.4, P.001, $w^2=394.1$, with youth age groups significantly displaying higher mean values on large field size , than to small field size. Figure 5 illustrates the nature of interaction and illustrates large field bar graphs are higher than small field bar graphs, this reveals and represents youth age group achieved significant greater mean values large field. The interaction effect further shows , F(2-94)=15.4, P.001, $w^2=394.1$, it is different for youth age groups on SSGs large field in comparison to SSGs small field, with youth age groups showing a significant difference in mean values for covering more

distance on large field compared to small field (table 9). Analysis revealed statistically significant interaction effect (u11,F=16358.4, P<.001; u12, F=998.7, P<.001; u13, F=1625.4, P<.001; u14, F=1412.7, P<.001; u15 F=, 1015.2, P<.001,u17/16,,F=1366.1,P<.001).

.



Figure 5: Displays youth age groups mean total distance covered (metres). Bar heights are mean values and error bars are 95% CI values.

4.3.2 Metres covered per minute

Main effect youth age groups in SSGs performance

Statistical analysis investigating age group effect for metres per minute covered, revealed a statistically significant main effect for youth age groups , F(2-94)=2862.0, P.001, w²=1.829, the main effect showed youth age groups significantly increased mean values scores across each different youth age group , with different mean values for each youth age group. Youth age group effect on SSGs performance showed significant difference (P<0.05) within large field metres covered per minute and effect size metres per minute, large field (mean \pm SD125 \pm 1.6) compared to small field, achieving significantly greater metres per minute than small field (mean \pm SD 109 \pm .5). It was found large field u/17/16s; u/15 players achieved greater metres per minute covered, (125mpm and 117mpm) in comparison to other age groups on large and small fields. All age groups achieved greater values on large field compared to small field values.

Main effect field size on age groups

Statistical analysis investigating metres covered per minute revealed a statistically significant main effect for field size, F (2, 94) =6941.7 P =<.001, w²=2.262, the main effect showed mean values were significantly higher in large field size compared to small field size. All Youth age groups showed significant difference (P<0.05) within
large field metres covered per minute and effect size metres per minute, large field (mean ± SD125±1.6) compared to small field, achieving significantly greater metres per minute than small field (mean ± SD 109±.5). It was found large field u/17/16s; u/15 players achieved greater metres per minute covered, (125mpm and 117mpm) in comparison to u/11s,12s.13s,14s, on large and small fields, All age groups achieved greater values on large field compared to small field values. Data demonstrates field size affected metres covered per minute from all youth age groups. Findings' showing it is different for youth age groups running performance within accumulation of increased metres per minute covered, on large field in comparison to small field.

Interaction effect field size and youth age groups

Field size and Youth age groups revealed a interaction effect, F(2-94)=28.7, P.001, w²=188 .7, with youth age groups significantly displaying higher mean values on large field size, than to small field size. Figure 6 illustrates the nature of interaction and illustrates large field bar graphs are higher than small field bar graphs, this reveals and represents youth age group achieved significant greater mean values large field size. The interaction effect, F(2-94)=28.7, P.001, $\dot{\eta}2 = .631$, w²=188.7, shows, it is different for youth age groups on large field in comparison to small field, with youth age groups showing a significant difference in mean values for covering more metre per minute on large field compared to small field (table 9) . All age groups achieved greater values on large field compared to small field values. Analysis revealed statistically significant interaction effect u11,(F=1658.6

P<.001,;u12 F=681.8, P<.001;u13, F=836.0,P <.001;u14,F=1274.1,P <001; u15 F=1124.8 P<.001 : u17/16 ,F=896.7,P <.001).



Error Bars: 95% CI

Figure.6: Displays youth age groups mean metres per minute results. Bar heights are mean values and error bars are 95% CI values. ..

4.3.3 Max velocity

Main effect youth age groups in SSGs performance

Statistical analysis investigating age group effect for maximum velocity speed covered , revealed statistically significant main effect for youth age groups,F(2-94)=810.6, P.001, w²=347.0, the main effect showed youth age groups significantly increased mean values scores across each different youth age group in SSGs performance, with different mean values for each youth age group. Youth age groups showed significant difference (P<0.05) within SSGs large field maximum velocity performance, in comparison to small field. Large field (mean \pm SD 6.4 \pm .046); achieved significantly greater maximum velocity than small field (mean \pm SD 5.0 \pm .046). The u/17, 16s, 15s achieved greater maximum velocity speed in large field (6.4(m/s) and 6.1(m/s)), in comparison to u14s, 13s, 12s, 11s small and large fields.

Main effect field size on age groups

Statistical analysis investigating maximum velocity speed revealed and a statistically significant main effect for field size ,F (2,94) =7954.6, P=<.001, w²=305.8,the main effect showed mean values were significantly higher in large field size compared to small field size.SSGs field size affected youth age groups maximum velocity achieved. Youth age groups showed significant difference (P<0.05) within large field

maximum velocity in comparison to small field. Large field (mean \pm SD 6.4 \pm .046); achieved significantly greater maximum velocity than small field (mean \pm SD 5.0 \pm .046). The u/17, 16s, 15s achieved greater maximum velocity speed in large field (6.4 m/s) and (6.1m/s), in comparison to u14s, 13s, 12s, 11s small and large fields. All age groups achieved greater values on large field compared to small field values. Data demonstrates field size affected youth age groups maximum velocity achieved. Findings' showed it is different for youth age groups running performance within accumulation of increased maximum velocity speeds achieved on large field in comparison to small field.

Interaction effect field size and youth age groups

Field size and Youth age groups revealed an interaction effect, F (2-94)=6.920, P.001, w²=560.6, with youth age groups significantly displaying higher mean values on large field size, than to small field size. Figure 7 illustrates the nature of interaction and illustrates large field bar graphs are higher than small field bar graphs, this reveals and represents youth age group achieved significant greater mean values large field size. The interaction effect ,F(2-94)=28.7, P.001, $\dot{\eta}2$ =.631, w²=188.7, shows, it is different for youth age groups on large field in comparison to small field, with youth age groups showing a significant difference in achieving higher maximum velocity mean values on large field compared to small field (table 9) . Analysis revealed statistically significant interaction effect (u11 F=1568.1,P<.001; u12F=1352. 0,P<.001;u13,F=878.1,P<.001; u14,F=1407.0,P<001; u15 F=12 13.8 P<.001 : u17/16, F=1841.3,P<.001).





Figure 7: Displays youth age groups mean maximum velocity results. Bar heights are mean values and error bars are 95% CI values.

4.3.4 Heart rate

Main effect youth age groups in SSGs performance

Statistical analysis investigating age group effect for maximum heart rate, revealed statistically significant main effect for youth age groups , F=280.0, P.001, $\dot{\eta}^2$ =.943, w²=6.240, the main effect showed youth age groups significantly increased mean values scores across each different youth age group with different mean values for each youth age group. Youth age groups effect on SSGs performance showed %HRmax responses increased with field size area becoming larger, increasing player physical workload. This showed significant difference (P<0.05), large field mean (%HRmax ±SD94.8±.36), achieved significantly greater than small field (%HRmax ±SD89.3±.74).All youth age groups mean percentage heart rate

maximum (%HRmax) responses in large field, induced highest mean values within u/17/16s. (94.8%HRmax) large field compared to small field (89.3. %HRmax).

Main effect field size on age groups

Statistical analysis investigating %HRmax revealed a statistically significant main effect for field size, F (2, 94) =280.0, P =<.001, w²=1.25,the main effect showed mean values were significantly higher in large field size compared to small field size. SSGs field size affected %HRmax achieved from youth age groups. All youth age groups %HRmax responses increased with field size area becoming larger, increasing player physical workload. u/17, 16s, achieved significant difference (P<0.05), (%HRmax) responses on large field (mean %HRmax ±SD94.8±.36) in comparison to u15s u14s, 13s, 12s, 11s., and in comparison to small field (mean ±SD89.3±.74).Data demonstrates field size affected youth age groups %HRmax achieved .Findings' showed it is different for youth age groups workload running performance within accumulation of increased %HRmax achieved on large field in comparison to small field.

Interaction effect field size and youth age groups

Field size and Youth age groups revealed an interaction effect , F (2-94)=41.2, P.001, w^2 =43.3, with youth age groups significantly displaying higher mean values on large field size , than to small field size. Figure 8 illustrates the nature of interaction and illustrates large field bar graphs are higher than small field bar graphs, this

reveals and represents Youth age group achieved significant greater mean values large field size. The interaction effect ,F(2-94)=41.2, P.001, w^2 =43.3, shows, it is different for youth age groups on large field in comparison to small field, with youth age groups showing a significant difference in %HRmax mean values on large field compared to small field (table 9) and significantly achieving higher %HRmax values Analysis revealed statistically significant large field. interaction effect ;u12 F=10553, P<.001;u13,F= 908.3,P<.001;u14,F= u11,(F=1055.3,P <.001 6274,P< 001; u15 F=430.2 P<.001 :u17/16 ,F=296.5, P<.001).It was further show within physical performance testing, U17/16 produced greater significant difference in maximal heart rate, (P < 0.05), compared to all other youth age groups. Post hoc tests showed Cohens d effect size comparisons for youth age groups found small E.S 0.0, u17/16 vs u/15,u/14, and small E.S 0.3, u17/16,u15,u/14 vs u11, 12, 13.Whilst small E.S 0.1 was found for u11,12,13.All mean ± SD comparisons are indicated in table 8.



Error Bars: 95% Cl

Figure 8: Displays youth age groups mean %HRmax results. Bar heights are mean values and error bars are 95% CI values.

4.3.5 RPE

Main effect youth age groups in SSGs performance

Statistical analysis investigating age group effect for RPE , revealed statistically significant main effect for youth age groups , F(2-94)=39.4, P = .001 ,w²=8.92 ,the main effect showed youth age groups SSGs performance, significantly increased in mean value scores across each different youth age group, with different mean values for each youth age group. All youth age groups, RPE responses significantly increased (P<0.05) as field size increased large field (mean±SD18.2±.463) achieving, significant greater RPE than small field (mean ±SD.15.7 ±.518).

Main effect field size on age groups.

Statistical analysis investigating RPE revealed a statistically significant main effect for field size , F(2,94)=819.0, P=.001, $w^2=1.25$, the main effect showed mean values were significantly higher in large field size compared to small field size. SSGs field size affected youth age groups RPE. All Youth age groups RPE responses mean values increased as field size increased large field (mean±SD18.2±.463), achieving significant greater (P<0.05) RPE mean values , than small field (mean ±SD.15.7 ±.518).lt was found on large field, u/17/16s; u/15 age groups RPE scored highest (mean±SD18.2±.463) in comparison to u/11s,12s.13s,14s (mean±SD17.2±.707) .All age groups achieved greater RPE values on large field compared to small field values. Data demonstrates field size affected RPE values from all youth age groups. Findings' showing it is different for youth age groups on large field, increasing RPE values within large field in comparison to small field.

Interaction effect field size and youth age groups

Field size and Youth age groups revealed an interaction effect , F (2, 94) = 969, P=.001, w2=.0156, with youth age groups significantly displaying higher mean values on large field size, than to small field size. Figure 9 illustrates the nature of interaction, illustrating large field bar graphs are higher than small field bar graphs, this reveals and represents youth age group achieved significant greater mean values large field size. The interaction effect ,F (2, 94) = 969, P=.001, w²=.0156 , shows, it is different for youth age groups on large field in comparison to small field, with youth age groups showing a significant difference in obtaining higher RPE responses on large field compared to small field (table 9).Analysis revealed statistically significant interaction effect u11,(F=143.6,P<.001;u12 F=173.8,P<.001; u13F=143.6,P<.001;u14,F=129.6,P<001,u15F,=1038,P<.001:u17/

16.F=1296,P<.001).



Figure 9: Displays youth age groups mean RPE results. Bar heights are mean values and error bars are 95% CI values

4.3.6 Summary

The key data results highlighted and addressed hypothesis and aims. It was shown player physical performance characteristics increased with age (P<0.05).

Key time motion results identified all youth age groups achieved significant difference (P<.001) on SSGs large field size. SSGs large field time and motion responses significantly provided greater total distance covered (metres) (P<.001), metres covered per minute, (P<.001), maximum velocity (P<.001), greater %HRmax (P<.001), RPE (P<.001) compared to SSGs small field. The proposed hypothesis of SSGs small field size would elicit greater task intensity in players physical and time motion responses in comparison to SSGs large field size was not supported, through thesis key data result findings.

Field Size Distance Covered ± SD	u/17,16	u/15	u/14	u/13	u/12	u/11
Small Field	988±17.7	923±7.4	835±7	743±6.5	710±4.9	690±4.9
Large Field	1166±9.5	1076±6.5	1016±10.2	936±12.5	862±7.0	825±7.0
Metres Per minute ± SD	u/17,16	u/15	u/14	u/13	u/12	u/11
Small Field	109±.5	100 ±1	91±.8	82±.6	78±.75	70±.7
Large Field	125±1.6	117±.8	109±1.4	102±1.5	92±.8	91±.8
Maximum velocity± SD	u/17,16	u/15	u/14	u/13	u/12	u/11
Small Field	5.0±.046	4.8±.046	4.4±.053	4.2±.046	4.0±.046	3.7±.088
Large Field	6.4±.046	6.1±.083	5.6±.053	5.4±.075	5.3±.086	5.1±.051
%HRmax ±SD	u/17,16	u/15	u/14	u/13	u/12	u/11
Small Field	89.3±.74	86.7±.70	85.5±.53	82.3±.51	81.7±.70	80±.75
Large Field	94.8±.36	93.8±.74	92±.53	91±.53	90±.83	88±.51
R.P.E ± SD	u/17,16	u/15	u/14	u/13	u/12	u/11
Small Field	15.7±.518	15.5±.535	15.1±.354	14.5±.518	14.6±.518	14.3±.518
Large Field	18.2±.463	17.7±.463	17.5±.535	17.5±.535	17.2±.483	17.2±.707

Table 9: Field Size, Age Groups Time/Motion/Heart Rate/RPE ± SD Results

5.0 Discussion

5.1 Physical performance

Our findings showed elite youth age group players anthropometric measurements increased with chronological age, within height, body mass occurring from u10 to u17 years. U10s mean height ranged from 142.2cm to 179.1 cm for u17 players, with mean body mass increasing progressively from 33.6kg for u10, through to 69.5kg for u17 players.

Physical Testing showed as youth group age increased, players became progressively quicker as found in sprint testing results, u10 covered 10m in 1.99 seconds, and 1.74 seconds for u17 players.U10s covered 20m in 3.54 seconds, and 3.01 seconds for u17 players.

With younger elite youth age group players body size being smaller in comparison to older elite youth age groups player within this study, this resulted in a maturational and physical difference in younger youth age group levels, which resulted in an inability to cover space and distance equal to older elite youth age groups players as found and reported in similar studies, Harley et al., (2010).

Findings showed significant differences (P < 0.05) in physical responses encountered by youth age group players (Table 9). Authors in previous research found SSGs large field size induce significantly higher (P < 0.05) heart rate responses in comparison to small field size (Owen et al 2011;Hill-Haas et al., 2009).Further, in large field size , it was recognised all youth age group players significantly spent greater time above 85%maximal heart rate compared to small field size, as realised and in accordance with other authors findings

(Rampinni,2003;Little,2006,2007;Hoff,2004;Sassi 2004;Hill-Haas et al, 2009; Katis et al, 2009; Rampinini et al., 2007).

Steed et al.,(1994),Dellal et al,(2012) recognised in profiling player activities within analysis of time motion on physiological markers, found players, are influenced through larger field size dimensions, giving support to our findings. Physical responses encountered can be explained to the influential factors placed on player's physical demands, in response to tactical positioning differences within movement, game competiveness, player motivation levels, stop, start, walk, rest, jog and sprint, sporadic nature of SSGs. Further explanation for differences found in running performance between u17, 16 + u15 youth age groups compared to younger youth age groups is the intermittent nature within high-intensity actions during SSGs play, favouring older players.

Physical performance tests further showed player $\dot{V}O_2$ levels increased chronologically with age, older youth age group players produced greatest estimated $\dot{V}O_2$ levels 53.1±2.8 ml·kg-1 · min-1.in compared to $\dot{V}O_2$ levels 35.4±1.12 ml·kg-1 · min-1.for younger youth age group players. The suggested proposed cause being a biological effect, as a consequence having larger mature body size and larger heart and greater lung capacity, with greater cardiac output and lung volume capacity, mature aerobic and anaerobic energy supply pathways, increasing glycogen supply, resulted in greater aerobic volume capacity and greater maximal cardiac output, in comparison to the young youth players small body frame size, shorter limbs and small heart and lungs ,resulting in less volume of lung capacity, and less $\dot{V}O_2$ levels obtained ,as a cause of having less cardiac output and lung volume volume influencing aerobic volume capacity and running performance.

Findings are supported and validated in similar findings from previous research studies, that found estimated VO₂ levels increased chronologically with age 41.2 ml•kg-1 • min-1.for 9 + age group (Hulse, 2010) and 69.8 ml•kg-1 • min-1. older youth players (McMillan et al., 2005). Further in comparison of older and younger elite youth players at end and start of puberty it was found greater VO₂ levels values in older youth players at end of puberty, were more physiologically advanced, demonstrated greater game running performance Strøyer et al, (2010). This is in accordance with Philippaerts et al, (2006) who found improvement of physical capacities improved chronologically with age, and given observed test result differences in age groups, (Table 4) gradual increases in youth age groups running performance was expected. The estimated VO2 levels values found, are considered to be of typical average range for elite youth soccer players, suggesting youth age ml·kg-1·min-1players in our study, had good, but not outstanding aerobic capacity (55-65 ml·kg-1 · min-1.Research findings realise youth soccer players have lower VO₂ levels compared to adult players, however Helgerud et al.(2001), found in youth players values of VO2 levels at levels of 64.3 ml•kg-1 • min-1.

5.1.1 Maximum Velocity Speed

This study found, speed was significantly different (P<0.05) between fields, with highest velocity speed performed in large field size formats. Large field (40x40) showed highest maximum velocity speed 6.4 for older youth age group player and 5.1 for younger youth age group players was obtained in comparison to small field size (20x20) values of 5.0 for older youth age group players and 3.7 for younger youth age group players.

U17/16 youth age groups reached greater velocity speeds of 6.4±.046 (m/s) on large field and 5.0±.046 (m/s) small field compared to u15, u14, 13, u, 12, u11 youth age groups. This finding is in accordance with Goto et al , 2015 , who found u11 to u16 premier league youth academy players running velocity speed increased through chronological age levels ,with older youth players achieving above 6.0(m/s), this replicates findings in other studies that show maximum velocity speed increases with maturity and age (Buchheit, 2014: Mendez, 2013),

Our finding show large field size allowed greater opportunity for acceleration to greater maximum velocity speed to be achieved due to larger space to allow players to achieve runs, involving longer gate strides to increase sprinting intensity, this finding was supported and in accordance with (Casamichana et al,2010), who realised greater maximum velocity speed was significant during SSGs on large field size compared to small field size . Within small field observations, it was recognised players with ability to accelerate quickly became restricted through encountering limited individual field area per player to generate increased acceleration speed to allow opportunity to achieve maximum velocity speed, as they would in large field.

Small field size dimension limited player running gate pattern ability of youth age groups, to accumulate speed, restricting a players running gate pattern of stride length, causing players to take shorter gate strides, and demonstrating an inability to lengthen stride, influencing their ability to accelerate to generate speed over an increased distance to reach maximum velocity potential sprint capability, to allow faster speed to be achieved. This was the consequence and response to smaller fields providing , less personal individual relative field space, further restricting player's speed potential and ability to accumulate or match similar maximum velocity speeds achieved in larger field dimensions.

It is further suggested from our findings, the actual complexity in short sporadic angled running patterns and dynamic movement of SSGs itself, may explain the inability of players running performance in obtaining greater maximum velocity speed.

This finding is consistent with Casamichana et al,(2010), who recognised lower maximum velocity speed was achieved when individual relative field area per player was small. Similar to our findings Little (2009) found SSGs played in large field size, provide players with more space and distance to achieve greater running speeds, players achieved quicker maximum velocity speed on large field size, supporting our findings.

Other studies have found both in adult and elite youth players, Haugen et al, (2014), Williams (2006), Little et al, (2005), greater maximum speed capabilities can be reached over greater distance between 20 metres to 40 metres. In accordance with this, Berthoin, (2001) found maximum velocity speed of 7m/s was attained over a distance of 28.7 m. Whilst Young et al, 2015, realised maximum speed over 10 m can only produce 45% of maximum speed, whilst over 20m allows 80% and over 40m allows 97% maximum speed, indicating a small portion of maximum speed and acceleration can only be developed before and after first 10 metres. Supporting larger field size area compared to small field size area, provide greater opportunity to obtain higher maximum velocity speeds, as realised within our SSGs large field size compared to small field size.

5.1.2 Total distance covered

Total distance covered increased with age, increasing on both small and large field sizes. Large field size produced larger values and stronger age effect compared to small field size. U17, 16, youth age group covered greater total distance 1166±9.5 m large field and 988±17.7 m small field compared to u15, u14, 13, u, 12, u11 youth age groups. This is in accordance with our study's findings for youth age group players yo-yo test results, were u/17, 16 youth age groups covered more distance compared to other u15,u14,u13,u12,u11 youth age groups .

As a consequence of effect of increased field size, youth age group player's total distance covered increased as age level increased, in response to effect of increased individual player relative field space becoming larger in comparison to less individual relative field space on small field. This resulted in greater distance to be covered on large field. Larger individual playing space stimulated greater time and motion physiological loads in players in order to reduce space through movement to become closer in proximity to opponents and team mates.

Larger field area size resulted within players having greater opportunity and ability to apply their natural full length gate strides to cover ground and accumulate increases in total distance covered.SSGs larger field area, allow full potential of player gate stride to be achieved as to the increased personal individual playing space per player and greater distance between team mates and opponents.

Our findings show distance covered improved through age levels and was influenced and relative to the effect of maturation differences in weight and height across age levels, influencing individual maximal-effort during exercise as recognised in similar studies (Mujika et al., 2009).Studies have reported onset of

puberty has an average age 13 years for boys and peak height velocity happens between 13 to 14 years (Stratton et al., 2004). Lower distance covered from younger youth players with in our study, can be associated to younger youth players delayed maturation process within energy pathways not maturing till late teens. Therefore it can be implied individual total distance covered performance measurements can be relative to a player's status of maturation.

5.1.3 Metres per minute covered

Large field size induced greater meters covered per minute (m.min – 1) with highest value 125 m.min – 1 for older youth age group players and 91 m.min – 1 for the younger youth age group player, in comparison to small field size m.min – 1 with 109 m.min – 1 for older youth age group players and 70 m.min – 1 for younger youth age group players.

U17/16s youth age group achieved greater metres per minute 125±1.6 mpm large field and 109±.5 mpm small field compared to u15, u14, 13, u, 12, u11 youth age groups. The higher VO₂max levels of older youth age group players, (table 9) can further explain u17, 16, and u15 youth age groups ability in SSGs to achieve higher running performances due to, larger body frame size, limbs and organs allowing for larger gate strides and increased cardio stroke volume output and lung capacity,

U17/16s youth age groups reached 125±1.6 m·min-1 and u15s 117±.8 m·min-1, in large field, this can be considered consistent in which was reported from other authors in studies for m·min-1.It was reported indoor soccer players reached 117.3 m·min-1; 121 m·min-1 and 118 m·min-1 (Barbero et al., 2008;Castagna et al., 2009; Barbero et al., 2007).

The consequence of the effect of SSGs small field size on players accumulating less meters per minute covered , was the cause effect off less available personal individual field space per player , causing players to become closer to team mates, resulting within player inability to use their natural running full length gate stride to accumulate increases in metres per minute covered, causing players to take shorter gate strides, and as a consequence less accumulation of metres per minute were covered. The smaller field caused more angled running movements due to less space to allow longer running distances to move to support team mates. Limited space was available to dribble ball, resulting with greater angled movements to become available as a passing option, as to closer vicinity of team mates to receive a pass.

Our findings are in agreement with Pereira et al., 2007, who found young Brazilian youth soccer players in SSGs, covered 105 m⋅min-1 at u15; 109 m⋅min-1 at u17 and 118 m⋅min-1 at u19 levels, finding large field size area influence greater time and motion responses, allowed longer sprint distance and increased length of sprinting time, compared to small, medium fields. Further recognising players in small, medium fields, spent greater time walking, resulting within low distance per minute covered in comparison to large field. Whilst furthermore, our results are in accordance with that found for preadolescents Spanish youth players, who recorded 100 m⋅min-1 during SSGs (Barbero et al., 2007), which is consistent with our findings of 102±1.5 m⋅min-1 for younger preadolescent youth players.

Further in line with our findings Harley et al, (2010), found chronological age difference impacted relative metres covered per minute in u/16 players covering 115.2 m_min-1 compared to u/13 players 103.7 m_min-1.

Casamichana et al.,(2010) in accordance with our findings, found in youth players, as SSGs field size increased as did meters covered per minute increase 125 m.min¹ large field,113 m.min¹ medium field and 87 m.min¹ small field. Therefore it can be implied individual metres covered per minute performance measurements within this study, can be relative to a player's status of maturation.

5.2 Aerobic / Anaerobic influence

Chronological age effect can be proposed as to why performance improved and increased through youth age group levels. Greater aerobic and anaerobic capacity and increased glycogen levels, in older youth players, allowed players to generate greater physical and time-motion responses due to biological maturity of elite youth player and influence of larger body size enhancing performance relative to physical attributes of speed and strength, power, endurance in adolescent youths. It has been reported in previous research youth players who are more biologically mature and advanced, perform better in games, in comparison to late maturing youth players, with a less developed aerobic and anaerobic pathway (Sherar et al., 2007).

Within soccer, elite youth players have different physiological and physical processes impacting performance, due to chronological age effect difference. Differences are based on players having maturation levels effecting aerobic and anaerobic capabilities, storage of glycogen capabilities and development in thermoregulatory processes (Alvardo, 2005; Rowland, 2007).

With younger youth age group players having less developed aerobic and anaerobic pathways, for conducting high intensity exercise, this results within ATP supply limitation and lower phosphofructokinase (PFK) activity resulting within

reduced glycolysis (Riddell, 2008), as a consequence, it can be expected sprint speed for younger youth age group players will be slower and less distance covered in activities of high intensity compared to older youth age group players, as found in this study.

Aerobic improvement is developed through high heart rate responses (McMillan, et al.,2005).Younger youth players have an immature aerobic and anaerobic capacity, compared to more physiologically developed older youth player, who has greater body muscle maturation distribution and greater aerobic and anaerobic power (Naughton et al., 2000; Nikolaidis, 2011).

However, as realised in this study, aerobic and anaerobic capacity will improve progressively as youth players age begins to increase, primarily through increased enzymatic activity, gains within muscle mass and body size and organs (Naughton et al.,2000).Authors have shown ,good correlations between distance covered and aerobic power in soccer performance (Krustrup et al.,2003,Bangsbo et al.,1992).

Within SSGs, players perform high intensity work load demands and forceful actions involving jumping, turning, sprinting and tackling, activating specific working muscle groups, require utilization of creatine phosphate (CP), and glycolysis from lactate producing energy system, activating glycolysis within the active working muscle cells and enzymes. Anaerobic training can improve player's ability to perform repeated levels of high intensity exercise. This form of training activates creatine kinase activity and glycolytic enzymes, resulting in rates of higher energy rate production in the player's anaerobic pathway, increasing player's ability to achieve greater workload duration and shorter rest ratio for recovery.

Authors have recognised , high intensity training elevates the concentration of muscle glycogen, important for performing repeated bouts of high levels of exercise

intensity (Reilly et al.,1998), but does not significantly affect the pool of creatine phosphate.

5.3 Heart rate

Within large field size all youth age group players heart rates were influenced, as a cause of increased amounts of dynamic movement and frequency of running demand placed upon players, in response to increased individual playing area per player in larger field size, creating greater space and opportunity to allow increased amounts of accelerations, decelerations, sprinting, changes of directions, braking, jumping and turning, and working at greater physical intensities for ball contact, through covering more distance, creating greater tasks in physical demands and responses.

Furthermore as a consequence to enlarged field size, heart rates increased in response to players performing increased game-related activities which demand increased physiological energy costs for general locomotion, involving sideways, backwards runs, dribbling, shooting, tackling and passing, contributing to greater overall heart rate demands, as in accordance within similar findings from other authors (Randers et al., 2010; Reilly et al., 1984).

Small field size in comparison found less physical task workload demands were encountered, due to decreased individual playing area per player resulting in shorter distances covered, closer proximity to opponents and team mates.

Heart rate findings did not support small field size providing greater task intensities as effect of large field size provided greater heart rate responses of 88%-94%HRmax in comparison to 80%-89%HRmax small field size. It was further

realised maximal heart rate responses in the younger youth age group players compared to mature youth age group players, was influenced and limited in response to smaller body size, resulting in smaller heart and lower stroke volume and lower lung size volume, which influenced lower aerobic capacity and maximal cardiac output of younger youth age group players, as in accordance with Stølen (2005), who found similar outcomes when comparing maximal heart rate responses during small and large field size formats.

Our research findings further showed, as youth age player's chronological age level increased, as did heart rate responses, with younger youth players obtaining 80% maximal heart rate small field size and 88% large field size. Whilst older youth players obtained 89% maximal heart rate small field size and 94% large field size, this reveals youth age players substantially spend parts of SSGs, frequently higher than 80% and above 90% maximum heart rate, indicating anaerobic glycolysis, made a vast contribution of overall provisions for player energy supply in all SSGs, similar to findings in previous studies (Ekblom, 1986; Hill-Hass et al., 2010).

In agreement with our findings, other authors found SSGs produces steady state intervals of high intensity training loads, resulting in 90-95HRmax responses in youth players, relative to 85% VO₂max (Impellizzeri et al., 2006; Dellal et al., 2008; Hoff, 2005; Little et al., 2007).

Hegerude et al,.(2001) found youth players ,hear rate responses took 1-2 minutes to reach 90-95% of HRmax ,other authors have recognised similar findings , with change to heart rate responses not instantly recognisable in short high intensity activity and immediately do not reflected true heart rate response, prior to heart elevating to true increased heart rate response (Achten et al.,2003).According to other authors, fast and short explosive muscle exercise at high intensity is

dependent on anaerobic systems metabolism, which influences inconsistency expressed in player heart rate beat per minute (Alexiou et al.,,2008;Rebelo et al,2012).Therefore in short duration of high maximal intensity exercise heart rate may be underestimated. To combat this SSGs game duration time, was of sufficient length, to allow players to produce valid measures of steady state heart rate levels.

Intensity of SSGs increased without changing or influencing player numbers in games, teams remained constant at 4v4, however game intensity was dependant on field size dimensions. Through enlarging small field size to large field size dimension, resulted in increased individual playing area per player, which increased players physiological loads encountered, as realised in increased heart rate responses for large field size compared to small field size. The speed and game intensity of play in large field size was faster due to ball being in play more compared to small field size were smaller area resulted within the ball leaving field more frequently, reducing game intensity workload demands. Furthermore, no goalkeepers were used in SSGs, this increased individual playing area per player, influencing distance covered in both small and large fields, as a consequence of increased space influencing workloads, in response to recovery runs from offensive positions to defensive positions to protect goal areas, impacting heart rate responses, as realised from other authors who found significant heart rate responses in SSGs involving no goalkeepers (Dellal et al., 2008).

As a consequence of greater time-motion displacement in total distance covered per metre, faster maximum velocity speeds and intensity of play in metres covered per minute (m.min – 1) on large field size, resulted in greater %HRmax for all youth age groups compared to small field size. Players spent significantly greater time above 85%maximal heart rate in comparison to small field size. Large field size

induced highest 94.8±.36 %HRmax value for older youth age group players and 88±.51 %HRmax for younger youth age group players, in comparison to small field size values of 89.3±.74 %HRmax for older youth age group players and 80±.75 %HRmax for younger youth age group players.

It is suggested, associated increased %HRmax during SSGs large field size formats are a result of larger field size space dimension, creating greater internal physical loads and external time motion loads. Distance increased between team mates and opponents, generating loads relevant to increased running stride frequency, increased sprinting distance to apply or evade pressure, technical actions and motor movement responses. Findings support large field size can be better applied, as a more appropriate physical, time and motion training stimulus to increase efficiency of players exercise intensities, fitness condition and utilization of tactical and technical skills, in comparison to small field size , further validated in similar studies. Our findings are in accordance with Casamichana et al, (2010), who found larger individual playing area combined with long enough playing time can result in more game time spent above 90% of maximum heart rate, greater percentage of mean heart rate, and higher ratings of perceived exertion. It was further found Owen et al. (2004) enlarging SSGs field size an extra ten metres caused heart rates to increase.

Rampinini et al. (2007) found 3v3, 4v4,6v6 SSGs large field produced higher exercise intensity workloads and greater RPE responses compared to 3v3,4v4,6v6 small, medium fields. However other authors have found contrasting findings, it was found 5v5 small and large field there was no significant difference or effect in heart rate responses in 4x4 minute bouts on players (Kelly et al., 2009).Whilst Jones et al., (2007) recognised when field size per player becomes larger, player involvement and

game intensity may decrease, recognising similar heart rate responses during 8v8 and 4v4 SSGs.

The contrast in different findings could be explained through varied methodology and applied differences in duration of bouts, numbers of bouts and rest breaks between bouts, player motivation levels to participate, game competitiveness, no coach encouragement, all influencing factors in player heart rate response. Hoff et al.,(2004) found SSGs can improve aerobic and anaerobic capabilities, when players spend time in high intensity exercise workload zones of up to 85%-95%HRmax, improving player's physiological development with increased VO₂max and maximum heart rate responses.

Our findings demonstrate intensities in large field format, had potential to improve \dot{VO}_2 levels, showing players reaching between 80% to 95% HRmax, on average players achieved above 85% HRmax,studies suggest ,anaerobic threshold is above 85% to 90% HRmax (Little et al.,2006).The monitoring of heart rate, allows for measurement and gauging of intensity of exercise, and is a valid indicator of level of exercise intensities (Achten et al.,2003), however, Florida-James et al.,(1995) ,recognised heart rate can be influenced through thermal stress, cardiovascular drift and player work rate load .It is was realised by authors with similar findings (Hoff et al., 2002, Impellizzeri et al., 2005) hear rate values in SSGs depends highly on effort and individual motivation . Within SSGs, players are free with no tactical restrictions, willingness is required from players to generate workloads to impact players physiologically, motivation levels were increased through the application of coach encouragement. It is important to recognise application of SSGs used for conditioning purpose may not be a beneficial training exercise for all youth aged group players who may require other methods of physical stimulation. The use of

heart rate monitoring and GPS data measurement should be maintained, (Dellal *et al.*, 2011), this will support and detect players failing to reach required workload intensities to stimulate physiological development (Little, 2009).

5.4 RPE

Player self-ratings for perceived exertion RPE responses ,further support effect of large field size as being perceived to demand greater task intensity within physical exertion , result of enlarged individual playing area per player ,increased motion displacement, involving running greater distances due to field size being more open to play ,increasing higher intensity of workloads ,resulting in increased maximum heart rates ,influencing players perception of exertion on large field size verses small field size. It was recognised on small field size, younger youth age group players obtained a self-rating perceived exertion rating of 14.3±.518 RPE, 20 Borg scale, whilst older youth age group players obtained a self-rating perceived exertion rating perceived exertion rating of 15.7±.518 on RPE scale .Whilst in comparison, on large field size younger youth aged group players obtained a self-rating perceived exertion score of 17.2±.707 on RPE scale responses, with older youth aged group players obtaining a self-rating perceived exertion score of 18.2±.463 on RPE scale.

Small field size heart rate intensity was lower and less distance was covered from players, as found in similar studies(Aguiar et al,2012) resulting in lower perceived exertion ratings from players, giving support and valid indication large field size stimulated and influenced player's perception view of perceived effort of physical workloads. Findings are consistent and in accordance with other authors who found player RPE increased with effect of increased field size, resulting in

increased heart rates and time-motion responses (Casamichana et al, 2010;Rampinini *et al.*, 2007).RPE responses in all youth age group player levels increased in line with heart rate responses increasing in both small and large field size dimensions. However RPE responses increased greatest in large field size dimensions, were heart rate and time-motion responses were greater.

Player's time and motion tasks resulted in increased youth aged group player load displacement, leading to greater perceived excretion. Findings suggest increased individual relative field size area per player increases player RPE responses, as similarly reported by Casamichana et al (2010), who found higher RPE and heart rate responses were recorded in 5v5 SSGs large field in comparison to small and medium fields, finding greater running distance and increased activity, combined with less periods of recovery in large field's stimulated greater physiological responses.

Evidence suggest RPE is an excellent indicator of intensity of exercise load players experience in soccer (Impellizzeri *et al.* 2004). It was found large field size had a more significant self-rate of RPE in youth players ,than small field size. This is consistent in previous findings in literature, identifying as volume of intensity of exercise loads increase, as does player perception of exertion (Dellal et al., 2012).

5.5 Hypothesis findings

The findings of this study rejects our proposed hypothesis of SSGs small field size would elicit greater task intensity within players physical and time motion responses in comparison to SSGs large field size. Findings revealed SSGs large field size elicited greater task intensity differences, which were significant within timemotion and physical responses in large field size compared to hypothesised small

field size. Our hypothesis was not supported, findings addressed an important issue in SSGs whether field size can limit the ability of players to accumulate speed and distance. This thesis provides valuable new GPS data for SSGs literature, providing and validating SSGs small field size, limit players potential to achieve greater speed and distance compared to SSGs large field size. At best SSGs small field sizes provide players opportunity to accumulate average speeds and distance covered. SSGs small field size fails to provide enough distance to allow higher velocity speeds, meaning, SSGs small field size have limited potential for players to accumulate distances of increased length to achieve high velocity speeds, meaning distance is crucial to allow player acceleration, which SSGs small field fail to provide.SSGs small fields size do not allow initiations of effort and appropriate stimulus for players to improve speeds without the accumulation of distance.

It is acknowledged through data collected in this study, SSGs large field size resulted in, greater time motion responses and physical workload demands. All youth age group players encountered and produced greater total distance covered, metres per minute, maximum velocity speed, heart rate and RPE response, as a consequence of covering greater distance, in response to encountering larger individual playing area of space per player to generate increased longer lengths of running opportunities over greater distance. This resulted in greater physiological demands placed on all youth age group player's external output and internal physical responses in comparison to small field size demands, where less distance was covered due to smaller individual playing area of space per player in the space per player. Findings showed small field size dimension constrained all youth age group players running activities in response to less space restricting opportunity in ability to express true physical potential.

This thesis aim was to investigate SSGs small field size and large field size effect on elite youth soccer players across a range of age-groups, with the hypothesis that small field size can provide and promote greater physical and time, motion responses within elite youth soccer players in comparison to SSGs large field size.

Our findings rejected our hypothesis and showed SSGs large field size offered a more significant effect, for providing greater physical and time motion responses, in comparison to SSGs small field. It was further found running performance within elite youth player age groups increased as chronological age increased.

This research study offers findings, SSGs large field size area offered players from each age group maximum optimal benefit within physical and technical performance, the explanation for this, was in the response to players encountering increased open areas of space.

Our research investigation further discovered SSGs small field area size restricted player running performance, the reason being, small field area size prevented speed and distance accumulation, and was further found to restrict player's technical abilities to perform dribbling skills in response to decreased area space.

The explanation for SSGs larger field size area, offering increased time motion data responses, was player's encountered greater available individual space to increase optimal running performance. Both SSGs large and small field size areas was recognised for being able to influence and restrict player performance through players encountering increased and decreased individual space. It was shown players differed from one and other, due to individuality, capabilities of age-group differences in ability and physical maturity levels to play in SSGs was evident.

In response to players encountering increased open areas of space in SSGs large field, greater maximum velocity speeds, greater total distance covered and greater metres covered per minute were obtained, with all youth age groups achieving increased optimal running performance. The explanation for this, larger field size area causes players to take longer gate pattern strides to cover greater open areas of space, resulting in and allowing increased optimal running performance.

SSGs larger field area further offered younger youth players in the early stages of development more suitability in developing technical skills, game awareness, increased time to think, make decisions, and control ball, due to the greater distances from opposition players. This promoted more involvement within the game, greater opportunity to receive more ball touches, receive more opportunities to control, shoot, dribble, pass, score goals and tackle less, allowing enhancement and development of technical skills at an early stage, and age within the player's development.. The player's decision making abilities are improved through problem solving game related situations, whilst improving awareness and concentration levels.

This research study has shown, SSGs small field size area constrains youth age groups running performance activities, the explanation being , in response to players encountering less space, limiting gate pattern of stride length, resulting within running patterns of shorter sporadic running and dynamic movement, causing an inability within players running performance to obtain optimal running performance. Players became restricted within their ability to accelerate quickly, as to the reduced space and closer in proximity to opponents and team mates, causing angled running,

preventing opportunity to accumulate increases in acceleration to achieve maximum velocity speeds.

This research has shown there is a link to SSGs field size area influencing a player's technical skills across the different field sizes and age groups. Small field size area resulted within all youth age groups , less running to support team mates and less technical actions of dribbling, less time for decision making and problem solving in game related situations, display of poor game awareness, in response to closer vicinity of other players limiting space and applying pressured situations. However, technical passing opportunities increased as a consequence of smaller field size area causing team mates to become closer in vicinity to receive a pass, whereas larger field size resulted in more technical dribbling and running opportunities in response to larger field size areas and the greater proximity between team mates and opponents. Evident was the variation encountered in individual players technical skill ability, tactical knowledge and decision making abilities and conditioning level in each particular youth age group.

Limited research exists regarding elite youth soccer players in SSGs, which make this surprising, as to amount of professional soccer clubs which develop elite youth players in their own academies. Elite youth soccer players in comparison to adult players experience physical demands which are different, influenced through youth player's maturation status.

With the introduction to GPS units to elite youth soccer players in professional soccer club academies, this can result in optimization performance of elite youth players in training and competitive games, through soccer specific age group analysis and regular assessment of elite youth players in training and games.

The game demands are consistent, across different age groups ranging from u/11 to u/16s of elite youth soccer players, however, with players biologically maturing while passing through relevant age groups, players should become faster, specifically within ages between u/14 and u/16, whilst level of maturation should be taken into consideration in relation to elite youth player performance capacity.

It must be recognised players used in this research study were elite youth soccer players .Data responses and measurements may be different if another level of player was used , such as amateur or non-elite players, player training history and level of physical condition would possible influence outcome of measurement results. The implication of findings is effect of SSGs field size and influential variable factors can be adopted and applied for training stimuli by fitness trainers and coaches, with confidence participating players physical workload demands and time motion responses will be challenged. This research study recognises coaches through manipulating influential factors as field size, player numbers, use of goalkeepers, and modification of playing rules can effectively manipulate the effect of SSGs field size on elite youth age group player's workload tasks and technical skills.

However, it is suggested inconsistency exists in present knowledge within soccer literature on SSGs field size dimensions,format,design best applied, player numbers, playing time, player ability, fitness levels, modification of playing rules and level of influence of coach encouragement ,best adopted to achieve gold standard level of SSGs application. Therefore difficulties arise within allowing true comparisons of results and conclusions of what is correct and which are accurate in present soccer research literature, due to varied methodology applied.

To allow better understanding for future researchers, relative to how influential factors can manipulate SSGs design and player workload tasks, and to help find a

conclusion which is reliable, further investigation is required. It is recommended greater attention with more care and thought should be given from coaching staff when considering choice of SSGs format and field size per individual player when attempting to improve elite youth player's physical condition.

It was realised running performance in elite youth soccer players was influenced through chronological age related differences impacting physical capacities. It was found older youth age group players demonstrated superior physical capacities, game awareness and intelligence in ability to perform more movements off ball to create space to receive ball and stay unmarked, whilst, younger youth age group players remained more stationary and demonstrated less game awareness knowledge, on how to create space and evade markers, which influenced timemotion and physical measurements.

It is recommended further investigation within future studies should address to seek a standardized dimension and methodology solution, best be applied in future SSGs studies. This may allow clearer understanding within variables and factors of influence and bias, which may affect outcomes and findings.

Further research investigations are required within assessment on impact of physical change resulting from player's growth in relation to aging in SSGs related running performance.SSGs field size influence and effect must be linked to the objectives for elite youth players physical, technical, tactical and time motion needs. Sport researchers in order to help overcome this issues and problem, must define a SSGs standard size area format for small and large fields which can be used in future research studies. Only with standardized methodologies and field size can effect of SSGs field size be truly measured.

6.1 Acknowledgements

I would like to acknowledge Dr Tony Westford and Dr Geraint Florida James both for their guidance throughout my continual academic development within this MSc Research Study. Achten, J. and Jeukendrup, A. E. (2003). 'Heart rate monitoring'. *Sports Medicine, 33* (7), pp. 517 – 538.

Aguiar M. Abrantes C. Maçãs V. Leite N. Sampaio J. Ibáñez, S. (2008). Effects of intermittent or continuous training on speed, jump and repeated-sprint ability in semi-professional soccer players. *Open Sports Sci J. 1, 15-19*.

Aguiar, M., Botelho, G., Lago, C., & Macas, V. (2012).'A review on the effects of small-sided games'. *Journal of Human Kinetics* 33, (1) 103-113.

Alexiou, H., and Coutts, A.J. (2008). A comparison of methods used for quantifying internal training load in woman soccer players . *International Journal of Sports Physiology and Performance*, *3*, 320-330

Alvarado M.U., (2005).Nutrition for young so3.3.1 Hear rate

3.3.2 Height......55

ccer players. International Journal of Soccer and Science, 3(1), 12–20.

Ament I;Gijsbertus; Verkerke ,J.(2009).Exercise and Fatigue. *Sports Med 2009; 39* (5):389-422
Aughey RJ. (2011). Applications of GPS technologies to field sports. *Int J Sports Physiol Perform.6 (3):*295–310.

Aroso J, Rebelo AN, Gomes-Pereira J.(2004). Physiological impact of selected game-related exercises. *J Sports Sci.* ;22:522.

Aziz,A.R, Chia.M and Teh,K.C.(2000).The relationship between maximal oxygen uptake and repeated sprint performance indices in field hockey and soccer players . *Journal of Sports Medicine and Physical Fitness*,*40*:195-200

Balsom P, Lindholm T, Nilsson J, et al. (1999).Precision football.Kempele: Polar Electro Oy, Balsom P. Precision Football. Kempele, Finland: Polar Electro Oy, 1999.

Baldwin J, et al.,(1999).Muscle IMP accumulation during fatiguing submaximal exercise in endurance trained men. *Am J Physiol;277:R295*.

Bangsbo, J., Nørregaard, L. and Thorsøe, F.(1991). Activity profile of competition soccer. *Canadian Journal of Sports Science, 16, 110–116*

Bangsbo, J. (1994), "The physiology of soccer – with special reference to intense intermittent exercise". *Acta Physiologica Scandinavica, 151 (suppl. 619).*

Bangsbo J, Mizuno M .(1988). Morphological and metabolic alterations in soccer players with detraining and retraining and their relation to performance. In: Reilly T, Lees A, Davids K, Murphy WJ (eds). *Science and Football. E & FN Spon, London, pp 114–24.*

Bangsbo J, Nørregaard L, Thorsøe F. (1991). Activity profile of competition soccer. *Can J Sports Sci*, (2): 110-6

Bangsbo, J. (1995). Fitness Training in Football: A Scientific Approach.,88-99 Bagsværd, Denmark: HO+Storm.

Bangsbo J .(2005). Aerobic and anaerobic training in soccer with special emphasis on training of youth players. *Fitness Training in Soccer I. HO & Storm, Bagsvaerd, pp 1–231.*

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

Bangsbo, J.,Lindquist,F.(1992).Comparison of various exercise tests with endurance performance during soccer in professional players. *International Journal of Sports Medicine, 13, 125 – 132.*

Bangsbo, J. (1994a). The physiology of soccer: With special reference to intense physical exercise. *Acta Physiologica Scandinavica, 150 (suppl. 619), 1-156.*

Bangsbo, J. (1994b). Energy demands in competitive soccer. *Journal of Sports Science s, 12, S5-S12.*

Bangsbo, J., Norregaard, L.Thorso, F. (1991). Activity pro® le of professional soccer. *Canadian Journal of Spor ts Science , 16, 110-116.*

Bangsbo, J., Marcello, F.I. and 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., Lindquist F.(1992).Comparison of various exercise tests with endurance performance during soccer in professional players. *International Journal of Sports Medicine, 13, 125–132.*

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

Barbero, J. C., Barbero, V. and Granda, J. (2007). Perfil de actividad durante el juego en futbolistas infantiles. *Apunts. Educación Física y Deportes 4, 33-41.*

Barbero, J. C., Soto, V. M., Barbero, V. and Granda, J. (2008). Match analysis and heart rate of futsal players during competition. *Journal of Sports Sciences 26, 63-73*.

Barbero, J.C. and Castagna, C. (2007). Activity patterns in professional futsal players using global position tracking system. *Journal of Sports Science and Medicine 6,08-209.*

Barbero-Alvarez JC., Coutts A., Granda J., Barbero-Alvarez V., Castagna C.(2009). The validity and reliability of a global positioning satellite system device to assess speed and repeated sprint ability (RSA) in athletes. *Journal of Science and Medicine in Sport, 13(2), 232–235.*

Berthoin S, Manteca F, Gerbeaux M, Lensel-Corbeil G. (2010). Effect of a 12- week training programme on maximal aerobic speed (MAS) and running time to exhaustion at 100 percent of MAS for students aged 14-17 years. *J Sports Med Phys Fitness;35: 251 – 256*

112

Buchheit,M,.Mendez,A,Villanueva,B.M,Simpson,P,Bourdon,C.(2010).Match running performance and fitness in youth soccer. *Int J Sports Med; 31: 818 – 825*

Buchheit,M,and Mendez-Villanueva,V.(2014). effect of age maturity and body dimensions on match running performance in highly trained under 15 soccer players. *J.Sports Sci 32:1271-1278*,

Carling, C. (2010). Analysis of physical activity profiles when running with the ball in a professional soccer team. *Journal of Sports Sciences, 28, 319-328*

Castagna, C., D'Ottavio, S., Granda, J. and Barbero, J. C. (2009). Match demands of professional Futsal: a case study. *Journal of Science and Medicine in Sport 12, 490-494.*

Catapult. (2009a). "Catapult." Retrieved 2 January, 2009, from *http://www.catapultin* novations.com/minimaxx.html

Catapult. (2009b). "Minimax V4 Gps Performance - Sprints," *Catapult Innovations, Melbourne, pp. 1-6.*

Capranica L., Tessitore A., Guidetti L., Figura F.(2001). Heart rate and match analysis in pre-pubescent soccer players. *Journal of Sports Sciences, 19, 379–384*

Carling C. Bloomfield J. (2010). The effect of an early dismissal on ensuing player work-rate in a professional soccer match. *J Sports Sci Med.* 13(2), 126-128.

Carling C., Le Gall F., Reilly T., Williams A.M. (2009). Do anthropometric and fitness characteristics vary according to birth date distribution in elite youth academy soccer players?. *Scandinavian Journal of Medicine & Science in Sports, 19, 3–9.*

Carling,Le Gall.,Reilly and Williams, (2009).Castagna C., D'Ottavio S., Abt G., 2003, Activity profile of young soccer players during actual match play.*Journal of Strength and Conditioning Research, 17, 775–780.*

Carling C., Bloomfield J., Nelsen L., Reilly T.(2008). The role of motion analysis in elite soccer, contemporary performance measurement techniques and work rate data. *Sports Medicine*, *38(10)*, *839–862*

Castellano J., Casamichana D., Julio Calleja-González J., San Román J., Ostojic S.M. (2011). Reliability and accuracy of 10 *Hz* GPS devices for short-distance exercise, *Journal of Sports Science and Medicine 10, 233-234*

114

Capranica,L.,Tessitore,A.,Guidetti,L. and Figura,F.(2001).Heart rate and match analysis in pre-pubescent soccer players. *Journal of Sports Sciences, 19(6), 379-384.*

Castagna, C., D''ottavio, S. and Abt, G. (2003). Activity profile of young soccer players during actual match play. *Journal of Strength and Conditioning Research*, *17(4)*, 775-780.

Castagna C., Manzi V., Impellizzeri F., Weston M., Carlos J.(2010). Relationship between endurance field tests and match performance in young soccer players. *Journal of Strength and Conditioning*, *24(12)*, *3227–3233*

Castagna, C., Impellizzeri, F., Cecchini, E., Ermanno, Rampinnini, E. and Barvero-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.

Castagna, C., Belardinelli, R., & Abt, G. (2005). The VO2 and HR response to training with the ball in youth soccer players. In T. Reilly, J. Cabri, & D. Arau´ jo (Eds.), *Science and Football V (pp. 462-464). London/New York:Routledge,Taylor & Francis Group*.

Casamichana, D., & Castellano, J. (2010). Time-motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: Effects of field size. *Journal of Sports Sciences*, 28(14), 1615-1623.

Chamari.K,Hachana,Y.,Kaouech,F.,Jeddi,R.,Moussa-Chamari,I.and.Wislof,U.(2005). Endurance training and testing with the ball in young elite soccer players. *British Journal of Sports 39,24-28.*

Chamari,K,.Hachana,.Y.,Ahmed,Y,B,.Galy,O,.Sghaier.,F.,Chatard,J.C.,Hue,O.and Wislof,U.(2004).Field and laboratory testing in young elite soccer players. *British Journal of Sports Medicine*, *38(2)*, *191-196*.

Chen, M.J., Fan, X, and, Moe.S.T., (2002). Criterion-related validity of the Borg ratings of perceived exertion scale in healthy individuals: A meta-analysis.*J. Sports Sci.* 20:873–899.

Clark, N.A., Edwards, A.M., Morton, R.H. and Butterfly, R.J. (2008). Seasonto-season variations of physiological fitness within a squad of professional male soccer players. *Journal of Sports Sciences and Medicine, 7, 157-165.*

Coutts, A. and Duffield, R. (2010). Validity and reliability of GPS devices for measuring movement demands of team sports. Journal of Science and Medicine in Sport 13, 133-135.

Davies CT. (1980). Metabolic cost of exercise and physical performance in children with some observations on external loading. *Eur J Appl Physiol Occup Physiol.;45(2–3):95–102*

Davis JM, Bailey SP.(1997). Possible mechanisms of central nervous system fatigue during exercise. *Med Sci Sports Exerc 29: 45–57*

Davis, J.A., Brewer, J., and Atkin, D(1992). Pre-season physiological characteristics of English first and second division soccer players. *Journal of Sports Science 10,541-547.*

Dellal, A., Logo-Penas, C., Wong, D. P., & Chamari, K. (2011b). Effect of the number of ball contacts within bouts of 4 vs. 4 small-sided soccer games. International *Journal of Sports Physiology and Performance, 6(3), 322–333*

Dellal, A., Jannault, R., Lopez-Segovia, M., & Pialoux, V. (2011a). Influence of the players numbers in the heart rate responses of youth soccer players within 2 vs. 2, 3 vs. 3 and 4 vs. 4 small-sided games. *Journal of Human Kinetics, 28, 107–114*.

Dellal, A., Hill-Haas, S., Lago-Penas, C. and Chamari, K. (2011b).'Small-sided games in soccer: amateur vs. professional players' physiological responses, physical and technical activities'. *Journal of Strength and Conditioning Research, 25, pp.* 2371 – 2381.

Dellal A. Chamari K. Pintus A. Girard O. Cotte T. Keller D. (2008). Heart rate responses during small-sided and short intermittent running training in elite soccer players: a comparative study. *J Stren Cond Res,.* 22(5), 1449-1457.

Dellal, A, Chamari, C,Wong, DP, Ahmaidi, S, Keller, D, Barros,MLR,Bisciotti, GN, and Carling, C. (2010). Comparison of physical and technical performance in European professional soccer match-play:The FA Premier League and La LIGA. *Eur J Sport Sci, 25: 25,93–100.*

Di Salvo , V., Gregson, W., Atkinson, G., Tordoffi, P., and Drust , B. (2009). Analysis of high intensity activity in Premier League soccer. *International Journal of Sports Medicine*, *30*, 205-212.

Di Salvo, V, Baron, R, Tschan, H, Calderon Montero, FJ, Bachl, N,and Pigozzi, F., (2007). Performance characteristics according to playing position in elite soccer. *Int J Sports Med 28: 222–227.*

Duffield, R., Reid, M., Baker, J. and Spratford, W. (2010) Accuracy and reliability of GPS devices for measurement of movement patterns in confined spaces for courtbased sports. Journal of Scienceand Medicine in Sport 13, 523-525

Dunbar , G.M.J. and Power K. (1997). Fitness profiles of English professional and semi-professional soccer players using a battery of field tests. In: T. REILLY, J. Drust, B., Reilly, T. and Cable, N. (2000). 'Physiological responses to laboratory based soccer specific intermittent and continuous exercise'. *Journal of Sports Sciences, 18, pp. 885 – 892.*

Drust, B., Atkinson, G and Reilly, T. (2007). Future perspectives in the evaluation of the physiological demands of soccer . *Sports Medicine* , *37*, *783* – *805*.

Drust, B., Rasmussen, P., Mohr, M., Nielson, B., and Nybo, L. (2005a). Elevations in core and muscle temperature impairs repeated sprint performance. *Acta Physiological Scandinavica* 183, 181-190

Ekblom, B. (1986). Applied physiology of soccer. Sports Medicine, 3, 50-60.

Ekblom, B. (1989). A field test for soccer players. Science and Football, 1, 13 – 15.

Ekblom B (1969). Effect of physical training on the oxygen transport system in man. *Acta Physiol Scand Suppl 328:5–45.*

Edgecomb S.J., Norton K.I., (2006). Comparison of global positioning and computerbased tracking systems for measuring player movement distance during Australian football., *Journal of Science and Medicine in Spor, 9, 25–32.*

Edwards, A.M., Clark, N. and MacFadyen, A.M. (2003). Lactate and ventilator thresholds reflect the training status of professional soccer players where maximum aerobic power is unchanged. *Journal of Sports Science and Medicine, 2, 23-29*.

Ebbeling C, Hamill J, Freedson P, et al. (1992). An examination of efficiency during walking in children and adults. *Pediatr Exerc Sci.;4(1):36–49.*

Fallon,K.E.(2007).Blood tests in tired elite athletes:expectations of athletes,coaches and sports science/sports medicine staff.*British Journal of Sports Medicine*,41,41-44.

Fanchini M, Azzalin A, Castagna C, et al. (2010). Effect of bout duration on exercise intensity and technical performance of small-sided games in soccer. *J Strength Cond Res. Epub*

Fanchini M. Azzalin A. Castagna C. Schena F. Mcall A. Impellizzeri F. (2011) Effect of bout duration on exercise intensity and technical performance of small-sided games in soccer. *J Stren Cond Res.* 25, 453-458

Florida-James, G & Reilly.(1993). The physiological demands of Gaelic football,

British Journal Sports Medicine, 1995 (29), 41-45

Football Federation Australia. Small-sided games handbook [online]. Available from URL: *ttp://www.penrithfc.com/SSG%20Handbook%20for%20clubs%2019Dec07.pdf* [Accessed 2015 March 10]

Gabbett T. (2006).Skill-based conditioning games as an alternative to traditional conditioning for rugby league players. *J Strength Cond Res 20 (2): 309-15*

Gamble P. (2004). A skill-based conditioning games approach to metabolic conditioning for elite rugby football players.*J Strength Cond Res; 18 (3): 491-7*

Gastin, PB. Bennet, G, and Cook, J. (2013). Biological maturity influences running performance in junior Australian football. *J Sci Med Sport 16:140-145*

Gastin,PB.Bennet,G.(2014). Late matures at performance disadvantage to their more mature peers in junior Austalian football.J Sports Sci 32:563-357,.

121

Goto H., Morris JG., Nevill ME., (2013). Match analysis of U9 and U10 English Premier League Academy soccer players using a Global Positioning System: Relevance for Talent Identification and development. *Journal of Strength and Conditioning Research, Epub ahead of print.*

Goto H., Morris JG., Nevill ME. (2015). Motion Analysis of U11 to U16 Elite English Premier League Academy Players. *J Sports Sci* 33:1248-1258

Gregson W, Drust B. (2000). The physiology of football drills. Insight; 3 (4): 1-2

Gregson, W., Drust, B., Atkinson, G., and Salvo, V.D.(2010).Match to match variability of high speed activities in premier league soccer. *International Journal of Sports Medicine* 31,237-242.

Grieve DW, Ruth GJ. (1966). The relationships between length of stride, step frequency, time of swing and speed of walking for children and adults. *Ergonomics.;9(5):379–99*

Haugen T, Tønnessen E, Espen; Shalfawi, Shaher AI; Thomas; Enoksen, Eystein. (2014). The effect of 40-m repeated sprint training on maximum sprinting speed, repeated sprint speed endurance, vertical jump, and aerobic capacity in young elite male. *Journal of Strength & Conditioning Research: -25 -9 - 2364-2370*

Harley J.A., Barnes C., Portas M., Lovell R., Barrett S., Paul D., et al., (2010). Motion analysis of match-play in elite U12 to U16 age-group soccer players., *Journal of Sports Sciences*, *28(13)*, *1391–1397*.

Helgerud, J., Engen, J. C., WislØff, U., & Hoff, J. (2001). Aerobic endurance training improves soccer performance. *Medicine and Science in Sports and Exercise*, 33(11), 1925-1931.

Helgerud J.(2004). Endurance and strength training for soccer players: physiological considerations. *Sports Med; 34 (3): 165-80*

Hoff, J., WislØff, U., Engen, L. C., Kemi, O. J., & Helgerud, J. (2002). Soccer specific aerobic endurance training. British Journal of Sports Medicine, 36(3), 218-221

Hoff, J.(2005). Training and testing physical capacities for elite soccer players. *J Sports Sci* 23: 573–582

Hoff J,Alm asbakk B. (1995). The effects of maximum strength training on throwing velocity and muscle strength in female team handball. *J Strength Cond Res; 9 (4):* 255-8

Hoff.J.Helgerud J.(2004).Endurance and strength training for soccer players. Physiological considerations. *Sports Med 34: 165–180*

Hill-Haas,S.V., Coutts,A.J.,Dawson,B.T.and Roswell, G. J. (2010).Time-motion characteristics and physiological responses of small-sided games in elite youth players: the influence of player number and rule changes'. *Journal of Strength and Conditioning Research*, *24*, pp. 2149 – 2156.

Hill-Haas, S. V., Dawson, B. T., Impellizzeri, F. and Coutts, A. J. (2011). 'Physiology of small-sided games training in football: a systematic review'. *Sports Medicine*, *41* (3), pp. 199 – 220.

Hill-Hass,S.V., Dawson,B.T., Coutts,A.J.,and Russell,G.J.(2009). Physiological responses and time motion characterristics of various small sided soccer games in youth players . *Journal of Sports Science*, *27*, *1-8*.

Hill-Haas SV. Rowsell GJ. Dawson B. Coutts AJ.(2009c). Acute physiological responses and time-motion characteristics of two small-sided training regimes in youth soccer players. *J Stren Cond Res*, *23(1)*, *111-115*.

Hill-Haas, S.V., Coutts, A.J., Dawson, B.T., & Rowsell, G.J. (2010). Time-motion characteristics and physiological responses of small-sided games in elite youth players: The influence of player number and rule changes. *Journal of Strength and Conditioning Research*, 24, 2149–2156.

Hill-Haas S. Coutts A. Rowsell G. Dawson B. (2008). Variability of acute physiological responses and performance profiles of youth soccer players in small-sided games. *J Sci Med Sport, 11, 487-490.*

Hill-Haas, SV, Dawson, BT, Coutts, AJ, and Rowsell, GJ. (2009).Physiological responses and time-motion characteristics of various small-sided soccer games in youth players. *J Sports Sci 27: 1–8*

Hill-Haas S, Dawson B, Coutts AJ, et al.(2009). Physiological responses and timemotion characteristics of various small sided soccer games in youth players. *J Sports Sci; 27(1): 1-8*

Hill-Haas, S.V., Rowsell, G.J., Dawson, B.T., & Coutts, A.J. (2009b). Acute physiological responses and time-motion characteristics of two small-sided training regimes in youth soccer players. *Journal of Strength and Conditioning Research,* 23(1), 111–115.

Hill-Haas, SV, Coutts, AJ, Rowsell, GJ, and Dawson, BT. (2009).Generic versus small-sided game training in soccer. *Int J Sports Med* 30:636–642

Hill-Haas S, Rowsell G, Coutts AJ, et al.(2008). Acute physiological responses and time-motion characteristics of two small sided training regimes in youth soccer players. *J Strength Cond Res; 22 (6): 1-5*

Hill-Haas S, Coutts AJ, Dawson B, et al. (2010). Time-motion characteristics and physiological responses of small-sided games in elite youth players: the influence of player number and rule changes. *J Strength Cond Res; 24 (8):2149-56*

Hulse, M., Morris, J.G., and Neville, M.E. (2012). A field-test battery for elite, young soccer players. *International Journal of Sports Medicine (In Press).*

Impellizzeri, F., Rampinini, E., Coutts, A., Sassi, A. and Marcora, S. (2004). 'Use of RPE-based training load in soccer'. *Medicine and Science in Sport and Exercise, 36, pp. 1042 – 1047.*

Impellizzeri, F., Marcora, S., Castagna, C., Reilly, T., Sassi, A. and Iaia, F. (2006) 'Physiological and performance effects of generic versus specific aerobic training in soccer players'. *International Journal of Sports Medicine, 27, pp. 483 – 492* Impellizzeri, F.M. (2007a). Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. *International Journal of Sports Medicine*, 28(3), 228-235.

Impellizzeri FM., Rampinini E., Marcora SM., 2005, Physiological assessment of aerobic training in soccer. *Journal of Sports Sciences, 23, 583–592.*

Ikai, Hoff J and Helgerud J.(2004).Endurance and strength training for soccer players. *Physiological considerations*. *Sports Med* 34: 165–180

Ikai, M., and Steinhaus.A.H.(1961). Some factors modifying the expression of human strength .*Journal of Applied Physiology 16:157-63*

Jeong,T.S.,Rielly,T.,Morton,J.,Bae,S.W. and Drust,B.(2011) Quantification of the physiological loading of one week of pre-season and one week of in-season training in professional soccer players . *Journal of Sports Science 29,1161-1166*

Jennings D, Cormack S, Coutts AJ, et al. (2010) .The validity and reliability of GPS units for measuring distance in team sport specific running patterns. *Int J Sports Physiol Perform.5 (3):328–41.*

Jones, S., & Drust, B. (2007). Physiological and technical demands of 4 v 4 and 8 v 8 games in elite youth soccer players. *Kinesiology, 39, 2, 150-156*

Jones, A.M.,and Doust, J. (2001). Limitations to sub-maximal exercise performance .In R.Eston and T.Reilly (eds), Kinanthropometry and Exercise Physiology Manual Volume 2: *Exercise Physiology(pp.235-262)*. London : Routledge.

Jones, D.A. (1981). Muscle fatigue due to changes beyond the neuromuscular junction. In Human Muscle Fatigue: Physiological Mechanisms. *178-96. London: Pitmann Medical*

Katis, A., & Kellis, E. (2009). Effects of small-sided games on physical conditioning and performance in young soccer players. *Journal of Sports Science and Medicine, 8*, 374-380

Kelly DM. Drust B. (2008). The effect of pitch dimensions on heart rate responses and technical demands of small-sided soccer games in elite players. *J Sci Med Sport.* 12(4), 475-479.

Koklu, Y. (2012). A comparison of physiological responses to various intermittent and continuous small-sided games in young soccer players. *Journal of Human Kinetics, 31, 89–96.*

Koklu,Y., Asci, A., Kocak, F.U., Alemdaroglu, U., & Dundar, U. (2011). Comparison of the physiological responses to different small-sided games in elite young soccer players. *Journal of Strength and Conditioning Research,25, 1522–1528*

Krustrup, P. and Bangsbo, J. (2001). 'Physiological demands of top class soccer refereeing in relation to physical capacity: effect of intense intermittent exercise training'. *Journal of Sports Science, 19, pp. 881 – 891*.

Krustrup P., Mohr M., Amstrup T., Rysgaard T., Johansen J., Steensberg A., et al, .(2003). The yo-yo intermittent recovery test: Physiological response, reliability, and validity., *Medicine and Science in Sports and Exercise Science, 35, 695–705.*

Krustrup, P., Mohr, P., Ellingsgaard, H., and Bangsbo, J.(2005). Physical demands during an elite female soccer game: importance of training status. *Medicine and Science in Sports and Exercise*, *37*, *1242–8*.

Leger, L.A., D. Mercerier, C.Gadadoury, and J. Lambert (1988) The multistage 20 metre shuttle run test for aerobic fitness. *J.Sports Sci.* 6(2):93–101.

Leger, L. A.,Lambert, J.(1982). A maximal multistage 20-m shuttle run test to predict _VO2max. *European Journal of Applied Physiology and Occupational Physiology,* 49, 1 – 12.

Le Gall, F., Carling, C., Williams, M. and 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.*

Little T and Williams AG. (2007). Measures of exercise intensity during soccer training drills with professional footballers. *J Strength Cond Res 21: 367–371*

Little T, Williams AG. (2005) Specificity of acceleration ,maximum speed, and agility in professional soccer players. *Strength Cond Res.(1):76-8*.

Little, T. (2009) 'Measures of exercise intensity during soccer training drills with professional soccer players'. *Journal of Strength and Conditioning, 21, pp. 367 – 371.*

Little T. (2009) Optimizing the use of soccer drills for physiological development. *Strength Cond J; 31 (3): 1-8*

Little T, Williams A.(2006).Suitability of soccer training drills for endurance training. *J* Strength Cond Res ; 20 (2):316-9

Mallo, J., Navarro.(2008). Physical load imposed on soccer players during smallsided training games. *The Journal of Sports Medicine and Physical Fitness, 48(2), 166-171*

Malina R.M.(2003). Growth and maturity status of young soccer. In Science and Soccer, 2nd Ed, New York: Routledge

Malina,R.M.,Bouchard,C.and Bar-or, O.(2004a). Growth, Maturation and Physical Activity 2nd Edition. *Human Kinetics, Champaign, Illinois*

MacLeod, H., Morris, J., Nevill, A. and Sunderland, C. (2009) The validity of a nondifferential global positioning system for assessing player movement patterns in field hockey. Journal of Sports Sciences 27, 121-128.

MacLaren, D., Davis, K., Isokawa, M., Mellor, S., & Reilly, T. (1988). Physiological strain in 4-a-side soccer. In T. Reilly, A. Lees, K. Davis, & W. J. Murphy (Eds.), *Science and Football (pp. 76-80).*

Marriott, J., Reilly, T. and Miles, A. (1993). The effect of physiological stress on cognitive performance in a simulation of soccer. In Science and Football (edited by T. Reilly, J. Clarys and A. Stibbe), pp. 261--264. *London: E. & F.N. Spon.*

Mazzetti SA. Kraemer WJ. Volek JS. Duncan ND. Ratamess NA. Gomez AL. Newton, RU. Häkkinen K. Fleck SJ. (2011) The influence of direct supervision of resistance training on strength performance. *Med Sci Sports Exerc.* 2(6), 1175-84.

Meeusen, R., Watson, P., Dvoraak, J. (2006). The brain and fatigue: New opportunities for nutritional interventions? *Journal of Sports Sciences, 24, 773 – 782*

Mendez-Villanueva A., Buchheit M., Simpson B.M., Bourdon P.C., 2013, Match play intensity distribution in youth soccer. *International Journal of Sports Medicine, 34,* 101–110

Metaxas TI., Koutlianos NA., Kouidi EJ., Deligiannis AP.(2005), Comparative study of field and laboratory tests for the evaluation of aerobic capacity in soccer players., *Journal of Strength and Conditioning Research, 19(1), 79–84*

McLellan CP, Lovell DI, Cass GC.(2011). Performance analysis of elite Rugby League match play using global positioning systems. *J Strength Cond Res.; 25 (6):*

1703-10.

McMillan, K., Helgerud, J. and Hoff, J. (2005) 'Physiological adaptions to soccer specific endurance training in professional youth soccer players'. *British Journal of Sports*

McMillan K, Helgerud J, MacDonald R, Hoff J. (2005) Physiological adaptations to soccer specific endurance training in professional youth soccer players. *Br J Sports Med*,39(5): 273-7

McMillan,K.,Helgerud,J.,Grant,S.J.,Newell,J.,Wilson,J.,MacDonald,R,Hoff,J. (2005a). Lactate threshold responses to a season of professional British youth soccer. British *Journal of Sports Medicine, 39(7), 432-436 Medicine, 39, pp. 273 – 277*

Mohr M, Krustrup P, Bangsbo (2003).J. Match performance of high standard soccer players with special reference to development of fatigue. *J Sports Sci.;21(7):519–28.*

Mohr, M., Krustrup, P., & Bangsbo, J. (2005). Fatigue in soccer: A brief review. *Journal of Sports Sciences, 23, 593 - 599.*

Naughton G., Farpour-Lambert N.J., Carlson J., Bradney M., Van Praagh E. (2000). Physiological issues surrounding the performance of adolescent athletes. *Sports Medicine*, *30*, *309-325*.

133

Nikolaidis PT. (2011). Anaerobic power across adolescence in soccer players. *Human Movement, 12(4), 342–347.*

Ohashi, J., H. Togari,and T. Takll. (1991). The distance covered during matches of the world class soccer players (Japanese). *Proceedings of the Department of Sports Science, College of Arts and Sciences, University of Tokyo, 25:1–5*

Owen A, Twist C, Ford P. (2004). Small-sided games: the physiological and technical effect of altering pitch size and player numbers. *Insight FACA J; 7 (2): 50-3*

Owen, A., Wong, D., McKenna, M. and Dellal, A. (2011). 'Heart rate responses and technical comparisons between small vs. large-sided games in elite professional soccer'. *Journal of Strength and Conditioning Research, 25, pp. 2104 – 2110*

Papaiakovou,G,Giannakos,A,Michailidis,C,Patikias,D,Bassa,E,Kalopisis,V.(2009). The effect of chronological age and gender on the development of sprint performance during childhood and puberty. *J Strength Cond Res* 23: 2568-2573

Petersen, C., Pyne, D., Portus, M. and Dawson, B. (2009) Validity and reliability of GPS units to monitor cricket-specific movement patterns. *International Journal of Sports Physiology and Performance 4, 381-393*

Phillips SM., Turner AP., Gray S., Sanderson MF., Sproule J.(2010). Ingesting a 6% carbohydrate-electrolyte solution improves endurance capacity, but not sprint performance, during intermittent, high-intensity shuttle running in adolescent team games players aged 12-14 years. *European Journal of Applied Physiology, 109, 811–821.*

Philippaerts RM, Vaeyens R, Janssens M, Van Renterghem B, Matthys D, Craen R, Bourgois J, Vrijens J, Beunen G, Malina RM. (2006) .The relationship between peak height velocity and physical performance in youth soccer players. *Sports Sci 24 : 221 - 230*

Piggot B, Newton M, McGuian M. (2009). The relationship between training load and incidence of injury and illness over a pre season at an Australian Football League club. *J Aus Strength Cond.;17(3):4–17.*

Platt, D., Maxwell, A., Horn, R., Williams, M., & Reilly, T. (2001). Physiological and technical analysis of 3 v 3 and 5 v 5 youth football matches. *Insight, 4(4), 23-24.*

Portas, M.D., Harley, J.A., Barnes, C.A., & Rush, C.J. (2010) The validity and reliability of 1-Hz and 5-Hz global positioning systems for linear, multidirectional, and soccer-specific activities. *International Journal of Sports Physiology* & *Performance 5,448-458*

Puga, N., Ramos, J., Agostinho, J., Lomba, I., Costa, O., & De Freitas, F. (1993).
Physical profile of a first division Portuguese professional soccer team. In T. Reilly, J.
Clarys, & A. Stibbe (Eds.), *Science and football II (pp. 40-42). London: E & FN Spon.*

Pyne, D., Petersen, C., Higham, D., and Cramer, M. 2010. "Comparison of 5- and 10-Hz Gps Technology for Team Sport Analysis," *Medicine & Sports Science in Sports & Exercise (42:5), pp* 337-337

Ramsbottom, R., Brewer, J. and Williams, C. (1988). A progressive shuttle run test to estimate maximal oxygen uptake. *British Journal of Sports Medicine*, 22(4), 141-144.

Rampinini E, Impellizzeri FM, Castagna C, et al. (2007).Factors influencing physiological responses to small-sided soccer games. *J Sports Sci 25 (6): 659-66*

Rampinini, E., Impellizzeri, F. M., Castagna, C., Abt, G., Chamari, K., Sassi, A., & Marcora, S. M.(2007).Factors influencing physiological responses to small sided soccer games. *Journal of Sports Sciences*, *25*(*6*), *659-666*.

Rampinini E, Coutts AJ, Castagna C, Sassi R, Impellizzeri FM. (2007). Variation in top level soccer match performance. *Int J Sports Med.;28(12):1018–24*.

136

Rampinini E, Impellizzeri FM, Castagna C, Azzalin A, Ferrari Bravo D, Wislo/ ff U. (2008).Effect of match-related fatigue on short-passing ability in young soccer players. *Med Sci Sports Exerc.;40(5):934–42.*

Rampinini E, Bishop D, Marcora SM, Ferrari Bravo D, Sassi R,Impellizzeri FM. (2007). Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. *Int J Sports Med.;28(3):228–35*

Rampinni, E., Bishop, D., Marcora, S.M., Ferrari Bravo, D., Sassil, R. and Reilly, T., Williams, A.M., Nevill, A. and Franks, A.(2000). A multidisciplinary approach to talent identification in soccer. *Journal of Sports Sciences, 18(9), 695-702*

Randers M, Mujikab I, Hewitt A, et al. (2010). Application of four dif-ferent football match analysis systems: a comparative study.*J Sports Sci.* ;28(2):171–82.

Rebelo A., Brito J., Seabra A., Oliveira J., Krustrup P.(2012). Physical match performance of youth football players in relation to physical capacity., *European Journal of Sport.*

Reilly, T.and Edwards. (2007). Altered sleep wake cycles and physical performance in athletes. *Physiology and Behaviour*, 90, 274-284.

Reilly,T, Deykin T. (1983) Effects of partial sleep loss on subjective states,psychomotor and physical performance tests. *J Hum Mov Stud* ;9:157–70.

Reilly,T, Marshall S. (1991) Circadian rhythms in power output on a swim bench.*J Swim Res; 72:11–3.*

Reilly,T, Waterhouse J, Atkinson G. (1997). Ageing, rhythms of physical performance, and adjustment to changes in the sleep–activity cycle. *Occup Environ Med; 54:812–6.*

Reilly, T., Hughes, M. and Yamanaka, K. (1992). Put them under pressure. *Science* and *Football*, *5*, 6-8.

Reilly,T.(1997).Energetics of high-intensity exercise (soccer) with particular reference to fatigue. *Journal of Sports Sciences, 15, 257 – 263.*

Reilly T, Bangsbo J (1998). Anaerobic and aerobic training. In: Elliott B (ed). Applied Sport Science: *Training in Sport. John Wiley, Chichester, pp* 351–409.

Reilly, T., & White, C. (2004). Small-sided games as an alternative to interval-training for soccer players. In T. Reilly, J. Cabri, & D. Araújo (Eds.), Science and Football V (pp. 355-358). London and New York:Routledge Taylor & Francis Group.

Reilly, T., Williams, A.M., Nevill, A., & Franks, A. (2000). A multidisciplinary approach to talent identification in soccer. *Journal of Sports Sciences, 18, 695-702.*

Reilly, T. (1997). Energetics of high-intensity exercise (soccer) with particular reference to fatigue. *Journal of Sports Sciences, 15, 257-263.*

Reilly, T. (2003a). Environmental stress. In Science & Soccer (pp. 165-184). Williams, A.M. & Reilly, T. (Eds.), 2nd Edition. London, UK: E & FN Spon..

Reilly, T. (2003b). Motion analysis and physiological demands. *In Science & Soccer* (pp. 59-72). *Williams, A.M. & Reilly, T. (Eds.), 2nd Edition. London, UK: E & FN* Spon..

Reilly, T. (2005). An ergonomics model of the soccer training process. *Journal of Sports Sciences, 23, 561-572.*

Reilly, T. (2007). Science of training: Soccer. London, UK: Routledge.

139

Reilly, T., & Ball D. (1984). The net physiological cost of dribbling a soccer ball. *Research Quarterly for Exercise & Sport, 55, 267-271.*

Reilly, T., Drust, B., & Clarke, N. (2008). Muscle fatigue during football match-play. *Sports Medicine, 38, 357-367.*

Reilly, T., & Mujika, I. (2008). Science and football in an applied context. In Reilly T (Ed.), Science & Sports: Bridging the gap (pp. 21-31). *Maastricht, Netherlands: Shaker Publishing.*

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, 87-89*.

Reilly, T.,(2007). The training process .In the Science of Training-Soccer: A Scientific Approach to Developing Strength,Speed & Endurance(pp1-19). London :Routloudge.

Reilly, T., Bangsbo, J., Franks, A., (2000). Anthropometric, & physiological predispositions for elite soccer. *Journal of Sports Sciences, 18, 669–683.*

Reilly, J. Clarys and A. Stibbe, eds, *Science and Football II. London: E. & F.N.SPON, pp. 98-103*

Reilly, T., Williams, A.M., Nevill, A. and Franks, A. (2000). A multidisciplinary approach to talent identification in soccer. *Journal of Sports Sciences, 18(9), 695-702*.

Reilly T, Bangsbo J, Franks A. (2000). Anthropometric and physiologitional cal predispositions for elite soccer. J Sports Sci; 18 (9): 669-83

Riddell M.C., 2008, The endocrine response and substrate utilization during exercise in children and adolescents., *Journal of Applied Physiology*, *105*, *725*–733.

Rudolf P., Václav B., (2009). Heart rate response and game -related activity of younger school-age boys in different formats of soccer game.*Physical Education & Sport, (1), 69–74*

Roan D. (2012) Football Association vote in favour of youth football changes [Online]. *Available:www.bbc.co.uk/sport/0/football/18236981.*

Robelo,A.,Brito,J.,Seabra,A.,Oliveira,J.,Drust,B.,and Krustrup,P.(2012) A new tool to measure training load in soccer training and match play. *International Journal of Sports Meicine*, 33(4),297-304

Rowland TW, Auchinachie JA, Keenan TJ, et al. (1987) Physiologic responses to treadmill running in adult and prepubertal males. *Int J Sports Med.* ;8(4):292–7

Rowland T. (2007). Thermoregulation during exercise in the heat in children: old concepts revisited. *Journal of Applied Physiology, 105, 718–724.*

Sampaio J, Garcia G, Maças V, Ibanez J, Abrantes C, Caixinha P. (2007).Heart rate and perceptual responses to 2×2 and 3×3 small-sided youth soccer games. *J Sports Sci Med.* 6(suppl. 10):121–122

Sassi R, Reilly T, Impellizzeri FM. (2004). A comparison of smallsided games and interval training in elite professional soccer players [abstract]. *J Sports Sci 22: 562*

Schantz P, Sjoberg B (1985). Malate–aspartate and alphaglycerophosphate shuttle enzyme levels in untrained and endurance trained human skeletal muscle. *Acta Physiol Scand 123:12A.*

Schutz Y, Chambaz A. (1997).Could a satellite-based navigation system (GPS) be used to assess physical activity of individuals on earth? *Eur J Clin Nutr. 51*(*5*):338–9.

Sherar, L.B., Baxter-Jones, A.D., Faulkner, R.A. and Russel, K.W. (2007). Do physical maturity and birth date predict talent in male youth ice hockey players? *Journalof Sports Sciences*, *25(8)*, *879-886*.

Silva, J. M. (1990). 'An analysis of the training stress syndrome in competitive athletes'. *Journal of Applied Sport Psychology, 2, pp. 5 – 20.*

Steed, J., Gaesser, A. G. and Weltman, A. (1994). 'Rating of perceived exertion and blood lactate concentration during submaximal running'. *Medicine and Science in Sport and Exercise, 26 (6), pp. 797 – 803*

Stolen, T., Chamari, K., Castanga, C and Wislof, U. (2005). *Physiology of soccer : an update . Sports Medicine 35, 501-536.*

Strøyer J., Hansen L., Klausen K.(2004). Physiological profile and activity pattern of young soccer players during match play., *Medicine and Science in Sports and Exercise Science*, *36(1)*, *168–174*.

Strudwick, A., Reilly, T. and Doran, D. (2002). Anthropometric and fitness characteristics of elite players in two football codes . *Journal of Sports Medicine and Physical Fitness*, 42:239-242.

143

Svensson, M.,and Drust, B.(2005). Testing Soccer players. *Journal of Sports Science* 23,601-618.

Van Gool, D., Van Gerven, D., & Boutmans, J. (1988). The physiological load imposed on soccer players during real match play. In T. Reilly, A. Lees, K. Davids, & W. J. Murphy (Eds.), *Science and Football (pp. 51 – 59). London/New York: E & F.N.Spon*

Vaeyens,R.,Malina,R.M.,Janssens,M.,VanRenterghem,B., Bourgois,J.,Vrijens,J. and Philppaerts, R.M. (2006). A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. *British Journal of Sports Medicine*, *40(11),928-934*.

Varley M, Aughey R. (2012). Validity and reliability of GPS for mea-suring instantaneous velocity during acceleration, deceleration, and constant motion. *J Sports Sci.;30(2):121–7.*

Waldron MT, Highton C, Worsolf J, et al. (2011). Movement and physiological match demands of elite Rugby League using portable global positioning systems. *J Sports Sci;29(11): 1223–30.*

Williams, A. M., Horn, R., & Hodges, N. J. (2003). Skill acquisition.T. Reilly, A. M. Williams (Eds.), *Science and Soccer (pp. 198-213). London, UK: Routledge*
Williams K, Owen A. (2007). The impact of player numbers on the physiological responses to small sided games [abstract]. *J Sports Sci Med*; 6 Suppl. 10: 100

Williams A M, Franks A. (1998). Talent identification in soccer. *Sport Exercise Injury,; 4: 159-165*

Williams A. (2000) Suitability of soccer training drills for endurance training. *The Journal of Strength & Conditioning Research 20 (2), 316-319*

Wisløff U,Castagna C, Helgerud J,et al.(2004).Maximal squat strength is strongly correlated to sprint performance in elite soccer players.*Br J Sports Med* ;38 (3):285-8

Wisløff U, Helgerud J, Hoff J. (1998) Strength and endurance of elite soccer players. *Med Sci Sports Exerc ; 30 (3): 462-7*

Wong L, Chaouachi A, Chamari K, Dellal A, Wisloff U. (2010).Effect of preseason concurrent muscular strength and high-intensity interval training in professional soccer players. *J Strength Cond Res; 24(3): 653-660*

Young WB, Hepner J, Robbins DW.(2012).Movement demands in Australian rules football as indicators of muscle damage. *J Strength Cond Res; 26(2):492–496).*

145

Young, W. B., Fahrner, B., & Harvey, J. T. (2015). Different methods of training load quantification and their relationship to injury and illness in elite Australian football. *Journal of Science and Medicine in Sport.*

Zerguini,Y.,Kirkendall,D.,Junge,A.and Dvorak,J.(2007).Impact of Ramadan on physical performance in professional soccer players. *British Journal of Sports Medicine*, *41(6)*, 398-400

6.3 Appendixes



Week-by-week Plan

- 8th /13th November 2014– Baseline procedures
- 20th-30th November Physiological testing of players
- 6th /18th December Physiological testing of players
- 21ST February 2015 Start Testing
- 21st March End Testing
- 1ST April Analysis of data
- 1st 30th May- Begin Write Up
- 1st June Introduction completed
- 15th June methods completed
- 30th June- results & discussion completed
- 15th July 2015- first draft completed





My name is William Gilogley and I am a Postgraduate student from the School of Sports and Exercise Sciences at Edinburgh Napier University. As part of my degree course, I am undertaking a research project for my Master's Degree year.

The title of my project is:

"An Analysis of the effect of small sided games training in elite soccer players"

This study will investigate the age group comparison of elite soccer players aged u/11s to u/17s within small sided games, investigating the physiological responses, and the effect of pitch size on the physiological demands and workload responses of players.

Participants will be required to participate within four bouts of 4-a-side small sided soccer games, 3x3 minutes on each small, medium, large size fields, on an astro turf 3G synthetic grass field, within Rangers Football Club Football Academy Centre, Murray Park, Milngavie, Scotland..The potential findings of the project will be useful and valuable as it will allow for an age group comparison within physiological responses of elite soccer players, enabling measurement of age-related differences in the physiological responses within elite players within small sided games. Only u/11s to u/17s players from Rangers Football Club Academy programme can participate within the study, and will be grouped according to their underage team (U11 to U17). Main exclusion criteria cover any individual not a Rangers Football Academy player. Other exclusions cover individuals who are under the age of 11 years and over the age of eighteen years, and players who are currently injured, will be excluded from the study. If you agree to participate within the study, you will be asked to fill in a consent form before you can take part.You will be free to withdraw from the study at any stage, without reason, and it will not affect your treatment. There may be a risk of experiencing physical discomfort, but the risk of injury or adverse effect over and above this is low.

All information/data will be completely anonymised. Your name will be replaced with a number, and it will not be possible for you to be identified in any reporting of the data gathered. Any data collected will be kept in a secure place to which only I have access. These will be kept until the end of the examination process and then destroyed. The results may be published in a journal or presented at a conference. If you would like to contact an independent person, who knows about this project but is not involved in it, you are welcome to contact my independent advisor Maggie Chapman. Contact details are given below. If you have read and understood this information sheet, any questions you had have been answered, and you would like to participate within our study, please complete our consent form.

Contact details of the researcher

Name of researcher: WilliamGilogley

Address: Edinburgh Napier University, School of Life, Sport and Social Sciences Sighthill Edinburgh EH14 1DJ

Email Address: 40063657@napier.ac.uk

Contact details of Independent Advisor

Name of Independent Advisor: Maggie Chapman

Address: School of Life, Sport and Social Sciences

Napier University, Sighthill Campus, Edinburgh, Midlothian EH14 1DJ

Email: m.chapman@napier.ac.uk





"An Analysis of the effect of small sided games training in elite soccer players"

I have read the information sheet with respect to this project and have an understanding of the nature of the project all that is required from me and how any information collected will be utilized. I understand that I am free to request any further information at any stage. I am also free to voice any concerns which I may have at any point, throughout my participation in the project.

I have read and understood the information sheet and this consent form. I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in this study.

I understand that I have the right to withdraw from this study at any stage without giving any reason.

I understand the risk of discomfort to myself, but the risk of injury or adverse effect over and above this is low and that suitable risk assessments will have been undertaken and approved through the University Health and Safety Department, with respect to all aspects of the project.

I agree to participate in this study.

Name of participant:

Signature of participant:

Signature of researcher:	

Date:

Contact details of the researcher

Name of researcher: William Gilogley

Address: Edinburgh Napier University, School of Life, Sport and Social Sciences Sighthill Campus, Sighthill Edinburgh EH14 1DJ

Email Address: 40063657@ napier.ac.uk





Parental / Guardian Information Statement

My name is William Gilogley and I am a Postgraduate student from the School of Sports and Exercise Sciences at Edinburgh Napier University. As part of my degree course, I am undertaking a research project for my Master's Degree year.

The title of my project is:

"An Analysis of the effect of small sided games training in elite soccer players"

This study will investigate the age group comparison of elite soccer players aged u/11s to u/17s within small sided soccer games, investigating the physiological responses, and the effect of pitch size on the physiological demands and workload responses of players.

Participants will be required to participate within three bouts of 4-a-side small sided soccer games, 3x3 minutes on each small, medium, large size fields, on an astro turf 3G synthetic grass field, within Rangers Football Club Football Academy Centre, Murray Park, Milngavie, Scotland. The potential findings of the project will be useful and valuable as it will allow for an age group comparison within physiological responses of elite soccer players, enabling measurement of age-related differences in the physiological responses within elite players within small sided games. Only u/11s to u/17s players from Rangers Football Club Academy programme can participate within the study, and will be grouped according to their underage team (U11 to U17). Main exclusion criteria cover any individual not a Rangers Football Academy player. Other exclusions cover individuals who are under the age of 11 years and over the age of eighteen years, and players who are currently injured, will be excluded from the study. If you agree for your child to participate in the study, you will be asked to fill in a consent form before your child can take part. Your child will be free to withdraw from the study at any stage, without reason, and it will not affect your child's treatment.All information/data will be completely anonymised. There may be a risk of physical discomfort experienced by your child, but the risk of injury or adverse effect over and above this is low.Your child's name will be replaced with a number, and it will not be possible for your child to be identified in any reporting of the data gathered. Any data collected will be kept in a secure place to which only I have access. These will be kept until the end of the examination process and then destroyed. The results may be published in a journal or presented at a conference. If you would like to contact an independent person, who knows about this project but is not involved in it, you are welcome to contact my independent advisor Maggie Chapman. Contact details are given below. If you have read and understood this information sheet, any questions you had have been answered, and you would like your child to participate within our study, please complete our consent form.

Contact details of the researcher

Name of researcher: WilliamGilogley

Address: Edinburgh Napier University, School of Life, Sport and Social Sciences Sighthill Edinburgh EH14 1DJ

Email Address: 40063657@napier.ac.uk

Contact details of Independent Advisor Name of Independent Advisor: Maggie Chapman Address: School of Life, Sport and Social Sciences, Napier University, Sighthill Campus, Edinburgh, Midlothian EH14 1DJ Email: m.chapman@napier.ac.uk





Parental / Guardian Consent Form

"An Analysis of the effect of small sided games training in elite soccer players"

I have read and understood the information sheet and this consent form. I have had an opportunity to ask questions about my child's participation.

Before signing this consent form, I have been given the opportunity of asking any questions relating to my child's participation and I have received satisfactory answers.

I acknowledge that I have read the participant information statement, which explains the aims of the study and the nature of the investigation, and everything within the statement has been explained to me to my satisfaction

I understand the risk of discomfort to my child, but the risk of injury or adverse effect over and above this is low and that suitable risk assessments will have been undertaken and approved through the University Health and Safety Department, with respect to all aspects of the project.

I understand that my child can withdraw from the study at any time without prejudice to my relationship to the

I understand that my child is, under no obligation to take part in this study.

I understand that my child has the right to withdraw from this study at any stage without giving any reason.

I agree for my child to participate in this study.

Name of child participating:

Signature of parent / Guardian

Signature of researcher:

Date: _____

Contact details of the researcher

Name of researcher: William Gilogley

Address: Edinburgh Napier University, School of Life, Sport and Social Sciences Sighthill Campus, Sighthill Edinburgh EH14 1DJ

Email Address: 40063657@ napier.ac.uk



Borg Rating of Perceived Exertion

- 6 No exertion at all
- 7 Extremely light
- 8

F

- 9 Very light
- 10
- 11 Light
- 12
- 13 Somewhat hard
- 14
- 15 Hard (heavy)
- 16
- 17 Very hard
- 18
- 19 Extremely hard
- 20 Maximal exertion