## Chapter 6: The Junior Golfer


### Abstract

In the context of golf, a key aspect of the role of a youth strength and conditioning coach is to help children establish habits and motivation for physical activity / training and to develop physical literacy allowing them to learn how to, perform more effectively on the golf course. This chapter explores aspects of training junior golfers, including growth and maturation status, biological vs chronological age, barriers to engagement and the training that children can do to help develop physical characteristics necessary for improved golf performance and longevity in the sport. In doing so, the chapter provides evidence to answer common questions such as: “Should children lift weights?” “Are children simply mini-adults?” “How can coaching be adapted when working with children?”. This chapter critiques the myths and evidence surrounding children’s strength and conditioning with emphasis on the training that children may engage in to aid their physical development and competence as they progress towards adult golf. The chapter’s pragmatic approach will help coaches foster effective training habits, monitor behaviour and performance, and ultimately encourage enjoyment of strength and conditioning sessions.


### Introduction:

A note on terminology: When used throughout this chapter, the terms ‘children’ or ‘junior golfer’ refers to all phases of growth from ‘early childhood’ (0-5 years), through ‘middle childhood’ (boys 5-12 years, girls 5-10 years) and into ‘adolescence’ (i.e. boys 12-21 years, girls 10-20 years) before reaching adulthood. Where a specific age range focus is required, the appropriate terminology will be used. The term ‘athlete’ represents any child who is engaging in strength and conditioning / physical activity / the sport of golf as they all have the potential to develop physical competencies through athletic development (i.e. the process of developing all physical characteristics throughout childhood).

In recent years, there has been an increasing body of research to help guide the coaching of children in sport and physical activity. In 2019, 35,000 children took part in school golf competitions across the United Kingdom (HSBC, 2020), and there were >300,000 registered junior golfers in Europe who accounted for 7.5% of total golfers (The R&A & The EGA, 2019). Despite participation levels, there remains a paucity of research into the training of junior golfers, limiting the influence on applied practice and interventions. This chapter draws on case studies, the author's experiences in applied settings, and supporting research from both golf and other sports. Evidence is provided to support coaches' understanding of key physiological concepts, considerations required when coaching junior golfers in strength and conditioning (S&C) environments and when discussing these areas with parents, coaches, and junior golfers themselves.

Early specialisation refers to selecting and intensely training for a single sport at the exclusion of others, all year-round, at a young age and focussing training and practice towards improving performance (Read et al., 2016). Early specialisation in children's sport has been under scrutiny in recent times due to the consequences it can have on a child's longevity in a sport. This, however, has not deterred the rise of various junior golf tours (e.g. U.S. Kids Golf, with the World Championships attracting >1600 children with categories starting for children aged <6 years (US Kids Golf, n.d.)) and many children focusing their attention to golf at an increasingly early age. In golf, this may affect the total volume of practice, training and competition undertaken by children and, if not carefully managed, result in overuse injuries, overtraining and burnout. Research has shown that these injuries are more likely in children who early specialise compared to those who engage in a diverse selection of sport and fitness activities (Hall et al., 2015; Jayanthi et al., 2015), because of the high workload and repetition of similar movements involved in the one sport. The causes of overuse injuries can be multifaceted, with training volume, early specialisation, and maturation status all having been shown as risk factors (Myer et al., 2015). Indeed, Lloyd et al., (2016) strengthen the argument

for junior golfers to be engaged in regular and progressive S&C sessions, highlighting that this approach can reduce the risk of overtraining and enhance physiological adaptations and performance. This is especially so where children may be physically underprepared and at risk of overuse injury because of high workloads associated with practice and competition and an absence of preparatory conditioning (Lloyd et al., 2016; Myer et al., 2011).

In late specialisation, a child will continue to engage in numerous sports or fitness activities until they are at least in the adolescent phase. Late specialisation allows children to develop many different physical competencies beneficial to golf. Motivation towards participation can often be higher, and their chances of injury reduced due to the child developing a resilience through physical literacy and many physical qualities (e.g. strength) to protect them against the demands of their sport (Blagrove et al., 2017), in this case golf. Regardless of a child's existing engagement in sport, all junior golfers should be encouraged to engage in regular physical activity and 'afforded the opportunity to enhance athleticism in an individualized, holistic, and child-centered manner' (Lloyd et al., 2016, p. 1491).

**Coach's perspective:**

From an applied perspective, junior golfers and parents are often keen to suggest that they are 100% focussed on golf as they believe that's what club, county or regional coaches want to hear. This is an immediate opportunity to begin the education and relationship with the golfer and parent(s) to work towards a common goal of creating an athlete before, or alongside, becoming a golfer. A discussion around the benefits of engaging in a multisport approach during early- and middle-childhood for improved golf performance can encourage time away from the sport and allow children to continue their passion for other sports without the guilt or perceived pressure of 'needing' to solely focus on golf.

**Benefits of early engagement in S&C**

Engaging junior golfers in S&C programmes from an early age affords many benefits. For example, in order to ensure junior golfers are able to self-manage their programmes and adapt their training to suit the context / environment in which they find themselves (e.g. when travelling, where it can be difficult to maintain consistent training and nutrition routines), these goals should be built into a systematic S&C programme. This self-management extends to the understanding of nutrition and hydration to both fuel their training and performance and provide adequate recovery post S&C sessions and on course play. S&C coaches are often responsible for establishing appropriate habits in the areas of physical preparation, fuelling and refuelling pre / during training and golf, and effective recovery strategies to include physical modalities, nutrition, hydration and sleep hygiene (e.g. discussing sleep hygiene packs for tournaments away from home – pillow, earplugs, eye-mask, black-out-blind etc.). With younger golfers relying on the input and support of parents, it is crucial that this education and habit formation is systematically disseminated wider than just the squad or individual golfers. Parents should be involved in the process as they can ensure resources are in place, where appropriate, and help with habit formation away from supervised sessions.

**How well do you know me?**

How well coaches know and monitor junior golfers and how they then adapt S&C interventions and coaching to respond to the child's particular wants, needs, training age and maturational status can ultimately impact on the golfer's acute performance, chronic adaptations and engagement in the sport. There is no single optimal solution to training children, and knowledge of biological as well as chronological age can help coaches develop personalised programmes. As Ehlert (2020) suggested, owing to the inter-individual differences in training responses between golfers, practitioners should ensure that individualised programmes are underpinned by testing and monitoring of the physical capacities of each junior golfer. This allows adjustments to be made through the monitoring of the psychophysiological response to any prescribed external load (see Chapter 2).

Considerations of the junior golfer's global cumulative workloads (i.e. training, golf and other physical activity loads; arbitrary units) are required to adapt S&C programming to suit the individual. Within this, it is important to consider Physical Education sessions in school, additional school and external sports training / competition, leisure time physical activity, golf practice (on and off-course) and tournaments. It is also critical to understand what rest days are built in and what the junior golfer and their parents / coaches perceive 'rest days' to mean. Applied, anecdotal experience tells us that a rest day can be perceived as 'just hitting balls on the range for an hour'. From a needs analysis and workload perspective it is a useful exercise to ask junior golfers to document a typical week of physical activity. This can highlight those that are either specialising on golf and those who are undertaking greater volumes / intensities and may find completing multiple S&C sessions each week a difficult proposition. It is important to align this information to the goals and expectations of the parents, coach, and junior golfer. This may involve careful negotiations around workloads associated with S&C sessions and those external to a set programme. Allowing the junior golfer the opportunities to take ownership of this is important with regards motivation and adherence to their long-term engagement with the S&C programme. Where sport is a key focus within their education setting there can be many demands placed on the child which need to be managed carefully and discussed with other coaches (both within golf and other sports) with regards to cumulative workloads and taking an integrative approach (Myer et al., 2011). Academic pressures can also take a toll on adherence to training and attendance at sessions. Around exam times, solutions to keep young golfers engaged can take the form of education around the benefits of physical activity in memory recall and retention of information (e.g. Mavilidi et al., 2016) – this can be an effective way of balancing continued S&C maintenance work with academic revision pressures. The minimal effective dose strategy (i.e. the minimum amount of training that is required to prevent reversibility – the loss of previously gained adaptations)

can be applied in these situations to ensure that the golfer is able to perform well in their academic setting without entering a reversibility phase of training.

Given the unique variety of demands placed on junior golfers, an effective solution to understanding a junior golfer's total workload (and more specific session training loads) can be to use an athlete monitoring system (Williams et al., 2018). This may be in the form of a mobile application which shares data to both the golfer, parents and coaches, or a log with athlete self-report measures completed prior to sessions and post-session calculated training load using Session Rating of Perceived Exertion (sRPE; see Bourdon et al., (2017)):

Training load (au) = sRPE x Session Duration

Ideally, monitoring of junior golfers' practice, competition and S&C would be conducted live (e.g. logging alongside their sessions as and when each shot is played with sRPE completed post-session). However, if the tools are not available then retrospective recall can be used as Hayman et al., (2012) have shown this to be a reliable method of monitoring in golf. In addition to session-based workloads, the inclusion of athlete self-report measures will allow the junior golfer and S&C coach to adjust programmes in line with the moderators of internal load (i.e. the psychophysiological response to training loads; see Chapter 2. Measures may include, but not limited to:

- Fatigue & energy levels
- Stress (non-golf)
- Motivation
- Sleep duration and quality
- Perceived recovery from previous activities / training

- Muscle soreness

There is a paucity of empirical research demonstrating the amount of practice and training junior golfers conduct on a session to session, weekly, monthly, seasonal, or annual basis and the impact this can have on performance and risk of injury. In the only study to date, Langdown et al., (2018) highlighted that there were significant variations in junior golfers' practice and tournament volumes from month-to-month. In particular, spikes in volumes occurred around the holiday periods (Easter and summer). This is unsurprising as these periods represent improved weather, and an increase in the number of tournaments and daylight hours available to them to practice and compete without any academic attendance requirements. Langdown et al., (2018) also stated that there were significant variations across the sample of 111 junior golfers from England Golf regional and national programmes (e.g. average monthly long game shots ranged from 146 to 4108 for those that logged practice sessions). With results revealing that the volume of long game practice junior golfers undertake is a small significant predictor of changes in handicap (Langdown et al., 2018) it is feasible to suggest that S&C programmes need to protect them against the effects of this volume and in particular, the significant changes in volumes (and workload) in a short duration. In many countries, the winter months lead to increasing use of range mats by juniors when practicing (and for some, this continues year-round). Cabri et al., (2009) stated that counterforces (i.e. the force of the impact between club and ball) are transmitted by the clubhead and shaft to the hands and arms. With practice mats being less forgiving than playing from the turf in spring and summer months, these impact forces may be increasingly damaging for the wrist, elbow, and shoulder. Floor surfaces aside, the volume of long game shots played may also play a role in increased injuries to other areas of the body, and subsequently, longer term overuse injuries. As an example, with lower back pain being a prevalent injury within golf, Edwards, Dickin and Wang, (2020) argue that adequate physical preparation through S&C adaptations can allow the body to manage the stresses of the golf swing. However, without clear evidence from longitudinal data collection it is challenging to argue a case for the impact of certain volumes of practice and tournament play (or to suggest guidelines to set individual limits), and also to define the role that S&C can

play in protecting junior golfers long term. Practitioners must, therefore, draw on other research which demonstrates the case for S&C's protective benefits and use it to educate and promote the benefits of integrative training to suit the various demands and goals of each child (Myer et al., 2011).

**Growth and Maturation**

Children grow at different rates with some children developing earlier or later than the 'average'. This can mean that, if two children are born on the same day, and share the same *chronological age*, they may be at very different stages of physical development and maturational status, i.e. their *biological age*. This inevitably creates gaps between individual children in terms of their potential athletic development and key golf metrics such as clubhead speed (CHS) and drive distance. In addition to potential variations in biological age, coaches should be aware of dates of birth when coaching a group of children formed based on chronological age (e.g. U14s). This can be explained by the 'relative age effect' (RAE; Andronikos et al., 2016) and can be a factor in athletic development pathways or squad selections (see RAE example: part 1). The RAE refers to the consequence of cut-off dates being used in sport and indeed in other walks of life, such as education, to classify age groups and therefore training squads. This can have a significant impact upon children on both sides of the equation (early / late developers) and mean that late developers often miss out on S&C coaching opportunities when not selected for squads (Lloyd et al., 2014).

**Relative age effect example: Part 1**

Dina and Sara are in the same school year and both are club golfers aspiring towards future county squad selection. Today is the 2nd September. Both girls are 10 years of age with their birthdays separated by just under a year. Dina was born on the 3rd September and Sara on the 30th August. This puts the girls almost 1 year apart in terms of chronological age. Add in biological age differences and it could go either way. However, in this example Dina is an early developer and Sara is a late developer.

Next day: 3rd September (Dina's birthday)

Dina – 11 years of age, but +2 years for biological age = 13 years of age biologically

Sara – still 10 years of age, but -1 year for biological age = 9 years of age biologically

The girls have a biological age difference of 4 years due to their chronological age and their maturation status. If the cut-off date to play in the U11 squad is 1st September, then Dina will effectively have a 4-year biological advantage over Sara.

If Sara does not get selected for the county's junior squad, she may find herself feeling rejected and demotivated towards golf. This may lead to her dropping out of the setting. Conversely, it may drive her to face the additional challenges, continue golf outside the county pathway, and come back to performance pathways / senior squads later in her adolescent years. Developing this resilience and returning later to, perhaps, be even more successful than Dina, is known as 'relative age reversal' (McCarthy et al., 2016).

Andronikos et al., (2016) explain that, based on the influence of additional challenges experienced throughout the development journey, children can close the RAE gap as they progress towards adulthood (see RAE example: part 2). It is important S&C coaches assess the maturation of children (every 3-4 months; Lloyd et al., (2014); Lloyd et al., (2016)) and their training age as additional components to provide insight into the growth and development of each individual child and set appropriate interventions (Lloyd et al., 2014). These assessments can be used to highlight periods of rapid growth, to align with levels of fitness, strength, motor

skill performance, and technical proficiency that we can expect from those individuals (Lloyd et al., 2016) and to help build interventions that increase resilience and motivation towards training (McCarthy et al., 2016). This also ensures that S&C interventions, from structure and priority perspectives, are matched to their maturational status and individual needs analysis while helping to nullify any impact of RAE on training and coaching opportunities.

**Relative age effect example: Part 2**

Building on the example of Dina and Sara – fast forward 8 years, they are now 18 years of age and Dina has caught up with Sara in terms of biological age. Recently, Dina has found herself struggling to win compared to in the past when she would have many physical advantages over opposition.

Sara: she has faced many physical and development challenges due to being a late developer. This has encouraged her to solve problems, hone her skills (e.g. using her short game to help her compete in early years) and wait for the physical advantages to come. Psychologically this may have been tough, but research shows that this can build resilience as she progresses into adulthood and higher levels of sport (McCarthy et al., 2016). Sara was most vulnerable to dropout in the earlier years where she was faced with the biggest challenges of competing against earlier developers.

Dina: The physical advantage that she may well have relied upon during her childhood has been removed. She may have become complacent as she was growing and not faced as many challenges. Not winning so easily, or as frequently, in comparison to her peers may affect her motivation, confidence and enjoyment of golf and training. She is more likely to drop out as an adolescent or young adult as she finds it harder to compete.

There are various methods used to assess maturation including x-rays or radiographs (considered gold standard), the Tanner criteria (Tanner, 1962) (which should not be used by coaches due to its invasive nature), somatic age assessment using longitudinal growth curve analysis and predictions of age from peak height velocity (PHV). The most applicable for S&C coaches is to use the latter two methods. These are non-invasive, easy to gather the required assessment data and can be regularly analysed in a spreadsheet with the appropriate equations used (Table 1).

PHV is the maximum rate of growth that will occur to all children between the ages of 12-16 for boys (Abbassi, (1998) reported a rate of ~9.5cm per year) and 10-14 for girls (Lloyd & Oliver, 2012) (Abbassi, (1998) reported a rate of ~8.3cm per year). Monitoring how far away from PHV each child is (see Table 1) provides valuable information to better influence assessments, training priorities and structures that coaches apply in coaching settings. Using the Youth Physical Development Model (YPDM; Lloyd & Oliver, (2012)) as a basis for training priorities, coaches can align interventions more effectively if they can accurately predict the maturational status of the junior golfer. S&C coaches must then adapt coaching sessions to consider each athlete's needs, reflected by their position on the YPDM and their biological age (maturation status) rather than just focussing on chronological age expectations.

Table 1 Method of predicting age from peak height velocity and maturity status (adapted from Sherar *et al.*, 2015)

| **Average age of maturity (see** Lloyd & Oliver, 2012; Malina et al., 2020**)** | | |
|---|---|---|
| **Maturity** | ~Age at PHV (years; male) | ~Age at PHV (years; female) |
| **Early** | <13.00 | <11.00 |
| **Average** | 13.00-15.00 | 11.00-13.00 |
| **Late** | >15.0 | >13.0 |

**A worked example of predicting years from PHV for a male**

**Maturity Offset = –9.236 + (0.0002708 x Leg Length & Sitting Height interaction) + (-0.001663 x Age & Leg Length interaction) + (0.007216 x Age & Sitting Height interaction) + (0.02292 x Weight by Height Ratio)**

| **Male / Female** | Male |
|---|---|
| **Age (years)** | 11.253 years |
| **Height (cm)** | 149.40 |
| **Weight (kg)** | 40 |
| **Leg Length (cm)** | 70.40 |
| **Sitting Height (cm)** | 79.00 |
| **Leg Length & Sitting Height interaction** | 70.40 x 79.00 = 5561.60 |
| **Age & Leg Length interaction** | 11.253 x 70.40 = 792.21 |
| **Age & Sitting Height interaction** | 11.253 x 79.00 = 888.99 |
| **Weight by Height Ratio** | (40.00/149.40) x 100 = 26.77 |

**Maturity offset = –9.236 + (0.0002708 x 5561.60) + (–0.001663 x 792.21) + (0.007216 x 888.99) + (0.02292 x 26.77) = –2.02 years from PHV**

**Age at PHV = current age – maturation offset**

**11.25 years – (–2.02) = 13.27 years (Average Male Maturer)**

**Implications of PHV**

As children progress through the prepubertal, PHV and post-pubertal stages of growth, coaches of both S&C and golf need to be aware of the specific implications this may have on performance, competence and psychological characteristics, such as motivation, confidence etc. As Lloyd et al., (2014) state, it is important that coaches understand how growth and training interact to ensure training programmes are designed to develop children's strength to protect them from injury. With mismatched, rapid growth in the long bones relative to muscular lengthening, young golfers may experience disruption to their previously demonstrated range of movement, neuromuscular function, and physical performance (Lloyd et al., 2014) (e.g. their ability to lift competently in the gym or swing the golf club to produce effective and desired ball flights). Practitioners may need to revise the complexity of S&C programmes during phases of rapid growth and reassure junior golfers, parents, and coaches that lower performance levels are to be expected. Additional coaching observations (e.g. through increased frequency of supervised sessions) may be appropriate and effective during this phase to ensure form and technique are maintained, therefore ensuring safety, and reducing injury risk. It is also important from an applied perspective that any decreases in flexibility during a period of rapid growth is (in most cases) attributed to the mismatch between the long bones and the muscles (Mills et al., 2017) and the differential timing of adolescent spurts in leg and trunk length, with acknowledgments made that the muscular lengthening and trunk growth will eventually address this imbalance (Philippaerts et al., 2006).

**Typical traits of junior golfers**

Various sports have evidenced that, while more frequent involvement in a sport increases risk of injury, it is those adolescents that are new to a sport, or have underdeveloped techniques, that have the greatest need for S&C intervention to reduce subsequent injury risk (e.g. volleyball, (Wasser et al., 2020), football, (Dvorak et al., 2000), golf (Cabri et al., 2009; Meira & Brumitt, 2010) etc.). This notion, combined with the understanding that positive impulse (PI) (i.e. the force exerted to change momentum over a given time, [force x time]) in the counter movement jump test is a significant predictor of CHS in golfers (Wells et al., 2019), means that it is important to note some typical traits from young golfers that enter a performance programme that may influence their injury risk and PI test results. These traits, albeit in anecdotal form, are presented from over a decade of experience and with obvious caution around individual variation and highlighting the need for one-to-one observation and needs analysis. From those with a low training age it is common to see limited lower limb and gluteal strength, and lower PI from the CMJ testing prior to S&C interventions (e.g. see Coughlan et al., 2020). Research highlights that lower limb injuries account for 29-89% of all injuries in high-school sports each year (sport dependent) and that identifying those at risk remains critical to continuing participation and improved performance (Rechel et al., 2008).

Smith et al., (2014) reported lower pre-intervention test results for unilateral lower limb, core, and functional hip strength for junior golfers, using a progressive single leg squat test (SLS). Additionally, Agresta et al., (2017) reported a significant improvement in SLS performance with chronological age but stated that there may be underlying biological reasons for this and highlighting that programme interventions could target single leg stability in order to improve overall functional performance. In young golfers there are often hamstrings and gastrocnemius / soleus flexibility / ankle mobility issues (anecdotally, more males present with this restriction) that may impact upon their ability to competently perform squatting patterns and generate impulse (e.g. see Panoutsakopoulos et al., (2021)) which may, in turn, contribute to ineffective posture and performance during the swing (see Langdown, 2015).

With decreased scapula upward rotation, reduced posterior tilting, and excessive scapula internal rotation all highlighted in shoulder conditions (Struyf et al., 2011) it is important to note that scapula instability is often presented by young golfers. Research states that a high incidence of shoulder protraction is normal during child development and that the prevalence of scapula instability can be as much as 70% of children between 7-12 years of age (Penha et al., 2005), but, that it will improve as part of growth. The instability of the scapula may impact upon the ability to externally rotate the shoulders (Ebaugh et al., 2006) which is required in the downswing (trail-side) and follow-through (lead-side).

VandenBerg et al., (2017) reported that restricted internal (medial) hip rotation is associated with increased risk of an anterior cruciate ligament (ACL) injury and with young golfers being encouraged to engage in other sports, a limitation here should raise concerns. Anecdotally, restricted internal hip rotation is more prevalent with adolescent male golfers and when compared to measures of external hip rotation. Research shows that limitations in the lead hip passive and active internal rotation can be a cause of lower back pain for golfers (Murray et al., 2009). Additionally, although there is less prevalence of hip rotation restrictions in young female golfers, those with low 'training ages' often show increased levels of knee valgus, both during squatting or lunging based exercises and jump testing, again linked to increased ACL injury risk. The use of CMJ impulse testing provides an immediate coaching opportunity to discuss the increased risk of ACL injuries and the implementation of strength-based training interventions. With this type of injury most likely to occur during adolescent years (Dai et al., 2012) it is in the junior golfer population that careful coaching observation and intervention needs to be applied. To help prevent knee valgus, especially during single leg ballistic tasks, it is important to strengthen the muscles surrounding the hip – the hamstrings and the gluteals, which play an important role in stabilising the knee over the line of the foot during pivoting, jumping and landing (Dix et al., 2019). While the sport of golf does not specifically require

these particular fundamental movement skills (FMS; foundation / basic locomotion, manipulation and stabilisation skills used in play and everyday life) to compete, the other sports and training that the junior golfer undertakes may require inclusion of explosive movements, such as jumping. The cueing of knee alignment during lunging and squatting patterns can help to form initial understanding of safe movement during training and help when progressing to more explosive activities (Westbrook et al., 2020). Teaching young athletes how to correctly pivot, land from jumps with greater knee flexion (with control) and with the knees facing straight ahead, over the toe line, is critical in injury prevention. The increased evidence supporting the relationship between lower body force production (e.g. impulse) and CHS (e.g. Wells et al., 2019) reinforces work from Suchomel, Nimphius and Stone, (2016) who stated that it is important for a foundation of muscular strength to be established, with increased technical competence (i.e. control over jumping and landing mechanics), prior to a greater emphasis being placed upon development of power, rate of force development and velocity-based training. This includes plyometric or ballistic exercises, which as Ehlert (2020) suggests, may elicit further performance gains in golf.

With all these common traits, it is important to reflect on the athlete's training age and participation in other sports.

> "*Training age* is defined as the amount of time accumulated from both periodic and longitudinal participation in training programs and sport related activities that foster the development of musculoskeletal health, basic movement patterns and overall physical fitness." (Myer et al., 2013; p.15)

Based on the quotation, a 10-year-old child who has been training with a suitably qualified coach since they were eight would have a training age of two years. We know from research that maturity-related differences in body size and motor skill performance begin to emerge around the ages of six–seven years (Malina et al., 2005). These developmental differences in

height and motor skill can make programming for children based on chronological age contentious (Myer et al., 2013) and highlight the need to establish specific needs and priorities for each individual child's S&C intervention.

Managing the training programme for a child who is new to golf but has competed at a high level in another sport presents an interesting situation. The child may have a training age of several years for the other sport and will, therefore, not be zero years for the sport of golf. Initial assessment of the physical characteristics and S&C related competence is required here to understand their status in terms of FMS, strength, mobility, agility, endurance etc. in line with both the YPDM, their needs analysis for golf and individual goals.

**Children are not miniature adults**

When training children, it can be an easy option to replicate programmes that adults complete. However, because children's physiology is in a constant state of change (e.g. fluctuations in hormones such as testosterone, growth hormone, and insulin-like growth factors associated with growth spurts (Lloyd & Oliver, 2012)), practitioners should not view or coach children as miniature-adults (Lloyd et al., 2016). There are many physiological differences that should impact on the design of S&C interventions. We know that a child's $\dot{V}O_{2Max}$ (i.e. the volume of oxygen that can be used by the body for energy production $kg^{-1}.min^{-1}$) is lower than an adult's, but that it increases progressively with age. With golf being a relatively low intensity sport, training to increase $\dot{V}O_{2Max}$ and cardiac output may be considered lower priorities when attempting to improve golf performance. However, from a youth physical development perspective, increasing overall fitness allows greater physical capacity and health benefits to potentially influence longevity in the sport.

**Hydration for children**

Hydration factors play a role in the quality of training that is achieved in each session and performance on the golf course. Indeed, research has shown that dehydration accounts for reduced cognitive function in various athletic populations (Grandjean & Grandjean, 2007; Wittbrodt & Millard-Stafford, 2018). However, there is currently no evidence to support differences in heat dispersal rates between adults and children and no evidence to suggest there are maturational differences in thermal balance or endurance performance during exercise in the heat. Research does show, however, that children have lower sweat rates due to smaller sweat glands with a lower sensitivity to ambient temperatures and less heat being produced by less muscle mass (Rowland, 2008). The heat generated increases as adolescents gain muscle mass and the greater force with which the muscles then contract during exercise (Falk & Dotan, 2008; Rowland, 2008). Establishing effective individualised hydration strategies around training with young golfers may help to engage them in monitoring processes and minimise any negative effects dehydrated states can have on both their training and golf performance. On the golf course, research points towards decreased performance with those starting the round dehydrated playing significantly more shots that those starting in a euhydrated state (Magee et al., 2017). Mild dehydration (i.e. a loss of 1.5% of body mass) has also been shown to reduce shot distance, decrease accuracy, and impair judgement of shot distance compared to euhydration (Smith et al., 2012).

**Practical applications**

As discussed, developing physical competence, and preparing children for golf performance (at whatever level) across the lifecourse, is not, and should not be, the same as when training adults. Additional considerations include attention spans, peer group socialisation, physical capabilities, and maturation status (both biological and psychological). The process of effectively supporting children in resistance training programmes, to benefit their golf, has been summarised well by Faigenbaum and McFarland, (2016), who introduce seven fundamental principles as the ‘PROCESS’ of youth resistance training. They highlight, that it is not just about meeting the priorities specified on the YPDM or in line with the PHV

predictions, elements of creativity, socialisation and, importantly, enjoyment, all need building into training sessions, whether coaching elite or novice junior golfers.

The following 'PROCESS' points are applied and adapted from suggestions of Faigenbaum and McFarland, (2016):

(a) Progression

The stress / workload expectations placed on the growing body must be progressed gradually. This does not mean increasing the load used each session, but that training stress and challenges (e.g. novel movement patterns or exercises) should progressively and consistently stimulate adaptations while maintain engagement in the S&C programme.

(b) Regularity

The frequency of training will depend on the junior golfer's training age, external workload to the S&C sessions and their individual needs. Two-three sessions per week is adequate for most youth athletes (Faigenbaum & McFarland, 2016). In applied settings, it has been a typical behaviour of junior golfers that S&C priorities and training regularity decreases during the summer months due to increased workload contributions from practice (on and off course) and tournament play. It is important to assist junior golfers to adapt training programmes to compliment the increased golf workloads and to avoid the principle of reversibility through the minimal effective dose.

(c) Overload

It is well known that to elicit adaptation the body needs to be stressed beyond the level to which the body is accustomed. Research has shown that gains of ~30-40% are typical in pre-adolescent children following 8-20 weeks of resistance training (Faigenbaum et al., 2009; Lloyd et al., 2014) and that initially bodyweight / free-weights are effective training modalities to improve measures of muscle strength (e.g. maximum voluntary contraction) in untrained children and adolescents (Peitz et al., 2018). To elicit such adaptations, progressive overload must take place through the

alteration of training frequency, intensity, time (or volume), and exercise selection. Faigenbaum and McFarland (2016) suggest guidelines to ensure children are progressed in an appropriate manner (Table 2):

Table 2 Youth resistance training progressions based on the golfer's training skill competence and muscular strength. Adapted from Faigenbaum & McFarland (2016).

| | **Low** | **Resistance Training Skill Competency** | **High** |
|---|---|---|---|
| **Sets** | 1-2 | 2-4 | Multiple |
| **Repetitions** | Varied | 6-12 | ≤6 |
| **Intensity** | ≤60%1RM* | ≤80%1RM | ≥85%1RM |
| **Exercise complexity** | Basic – introduce single and multi-joint exercises using a combination of body weight and free weights* | Intermediate – Introduction to more complex lifts (e.g. variations of Olympic lifts) | Advanced – Use of multi-joint exercises such as Olympic lift variations may be incorporated, provided the technical proficiency remains high |
| **Frequency** | 2/wk | 2-3/wk | 2-4/wk |
| | **Low** | **Muscular Strength** | **High** |

Note. There are no fixed boundaries between low and high competency / strength. These are continuums on which the coach and junior golfer must use coaching, observations, assessments, and progressive overload to determine when to increase each component. Where other training priorities are the focus (e.g. hypertrophy) the reps, sets and intensity may vary from these suggestions for strength. *Progress training competence to sufficient level to allow accurate 1RM to be established through testing (use predictive methods, e.g. calculating 1RM from ≤10RM)

Athlete self-report measures are a useful tool to inform intervention adjustments to ensure appropriate overload. As junior golfers increase their training age and become familiar and competent in and around a gym environment their levels of responsibility, to monitor their own global workload and adjust accordingly, should be increased. This will ultimately benefit them when away at tournaments and in any unsupervised sessions.

(d) Creativity

Getting young golfers to 'buy in' to S&C programmes can mean overcoming barriers, myth busting education and igniting their imagination to overcome preconceived perceptions of what S&C or 'training for golf' looks like. The creativity of the coach to use appropriate exercises, equipment, and programming to meet the needs of each individual requires ingenuity and a flexible, innovative approach. Fostering an environment in which the junior golfer feels comfortable and supported to achieve adaptations through S&C will ultimately increase exercise adherence, thus contributing to the previous factors of progressive overload and regularity. Agans et al., (2013) propose that young people need positive movement experiences (PME) and to be behaviourally, cognitively, and emotionally engaged to benefit from participation. It should be noted that this does not mean using different exercises each session, or indeed recreating golf specific movements in the gym. Simply promoting the benefits of S&C to young golfers and using role models can be enough to stimulate initial engagement with the programme. Bailey et al., (2013) state that it is vital that coaches' behaviours and practices match the needs of the young athlete. Fostering autonomy and choice through challenges posed to the children will further engage them in the sessions and help focus them towards their goals. Creativity is also valuable when it comes to designing S&C programmes for those junior golfers training at home (when unsupervised), and those who have disabilities and require modifications to exercises in order to continue to achieve their training goals.

(e) Enjoyment

The training age of the junior golfer is important here. Matching the programme's skill demand to their level of competence in the gym will ensure they perceive their sessions and programme to be appropriate and enjoyable. As alluded to by Agans et al., (2013) and Bailey et al., (2013), the goal with junior golfer S&C programmes in the first instance has to be adherence through PME, enjoyment and perceived competence through skill development. Many junior golfers enter regional development programmes having very young training ages and low competence in a gym environment, therefore the use of positive coaching behaviours, athlete choice and potentially inspirational role models, in the sport of golf, can offer benefits to motivation, engagement and enjoyment in sessions (see Bailey et al., (2013)).

(f) Socialisation

Although golf is, in the main, an individual sport there are still squads and opportunities to engage junior golfers through common S&C goals across groups. Faigenbaum and McFarland, (2016) argue that, increases in muscular strength can be maximised when socialisation is prioritised by the S&C coach and juniors can work towards common goals. They also state that socialisation can increase adherence and enjoyment which, ultimately, will allow S&C coaches to achieve progressive overload through regular attendance at sessions and adaptations achieved through training. Group training sessions may foster an element of healthy competition, that as long as technique and form is not compromised, can allow junior golfers to appreciate where they are in line with their own and others' expectations.

(g) Supervision

Despite lots of recent research into youth physical development, some myths still exist surrounding the use of resistance when children train for fitness or sport (see Benjamin & Glow, (2003); Lloyd et al., (2016)). As coaches we need to understand that although there is no minimum age to lifting weights, the child must be ready to enter and engage safely in a training environment that is suitably supervised. The supervision principle is crucial here. Coaches need to ensure they are appropriately qualified to be coaching

children in resistance-based training (or S&C) sessions. Equally, parents of a junior golfer who is looking to engage in S&C, should seek out those with appropriate qualifications (e.g. United Kingdom Strength and Conditioning Association (UKSCA) or National Strength and Conditioning Association (NSCA) accredited S&C coach) and experience of working in the sport of golf (i.e. demonstrable understanding of the demands of golf and has an appreciation for research in the field).

Case studies from applied work have highlighted occasions where a junior golfer is being supported by a 'trainer' with limited understanding of testing or programming for children, or more specifically, junior golfers. While it is commendable and encouraged for fitness instructors / golf coaches to expand their knowledge of S&C techniques, applied to golf, S&C interventions should be provided by a qualified and experienced coach. Without an in depth understanding of the science underpinning physiological adaptations (elicited through S&C) and the demands of the sport, it is difficult to maximise the gains a junior golfer can make towards their goals. Injury risks can be reduced and skill based competence (especially those with young training ages) can be maximised by having S&C sessions / programmes and by adhering to this supervision principle (Faigenbaum & McFarland, 2016). Building effective communication channels and establishing relationships with parents allows education and awareness to be raised allowing them to make informed decisions and also support their child's training.

When supervising sessions, it is important the S&C coach considers the level of expectation they place on each junior golfer and how this is shown. This will be very subjective in nature and possibly different for each child. However, coach expectations for each child should remain high enough to ensure a ceiling is not placed on the child's perceived potential. Keeping expectations above where the child currently is (albeit at

an appropriate level above), can maintain their self-belief and positive attitude. This is, again, important for parents and other coaches to provide aligned messaging to maximise the gains that supervised and unsupervised sessions can have.

While the 'PROCESS' (Faigenbaum & McFarland, 2016) is there to guide S&C coaches it is essential to listen and communicate with the junior golfer and their support network. Communication, in this regard, is vital to resolve potentially conflicting demands being placed on the junior golfer. At each moment in time consideration must be given to what the overarching priorities are for the child and their parents. These will often shift throughout the academic year, and especially so during exam seasons, with greater expectations coming from academic influences compared to golf and training. As previously mentioned, being able to adapt their programme and frequency of supervised sessions will be important to help maintain focus on key academic priorities without negating the positive impacts that training can have on stress, cognitive function, memory recall etc., during busy periods of revision (Lambourne & Tomporowski, 2010). The junior golfer's training needs during these periods may simply be to act as a distraction from other demands. Communication, an understanding approach, and adaptability are positive coaching behaviours required to ensuring achievement of goals in all areas.

**Conclusion:**

To influence the design of systematic programmes, S&C coaches of junior golfers should prioritise the considerations discussed within this chapter, ensuring the needs of each individual are met. Specifically, S&C coaches should ensure the seven 'PROCESS' principles, suggested by Faigenbaum and McFarland, (2016) allow training to be gradually developed while promoting sustained engagement and positive movement experiences. It is vital for coaches to use evidence-based education to dispel myths around a minimal age for children to lift weights, while ensuring each child is mature enough to remain safe in the training

environment. Children are not miniature adults; they respond differently to exercise compared to adults and this should be evident in programme design and education around the moderators of internal load. Coaches should provide programmes that protect children from the increased risk of overuse injuries through greater rest and recovery and consider that training age will dictate the frequency of training, with young training ages starting at 2-3 sessions per week. Training should also prioritise movement (FMS) and resistance training in relation to each golfer's maturation status, while monitoring of load and athlete self-report measures should provide insight to optimise programme amendments. Above all, coaches should endeavour to promote sustained S&C engagement through sessions that develop autonomy and are creative and enjoyable for all young golfers.

**References:**

Abbassi, V. (1998). Growth and normal puberty. *Pediatrics*, *102*(S3), 507–511.

Agans, J. P., Säfvenbom, R., Davis, J. L., Bowers, E. P., & Lerner, R. M. (2013). Positive movement experiences: Approaching the study of athletic participation, exercise, and leisure activity through relational developmental systems theory and the concept of embodiment. *Advances in Child Development and Behavior*, *45*, 261–286. https://doi.org/10.1016/B978-0-12-397946-9.00010-5

Agresta, C., Church, C., Henley, J., Duer, T., & O'Brien, K. (2017). Single-leg squat performance in active adolescents aged 8-17 years. *Journal of Strength and Conditioning Research*, *31*(5), 1187–1191. https://doi.org/10.1519/JSC.0000000000001617

Andronikos, G., Elumaro, A. I., Westbury, T., & Martindale, R. J. J. (2016). Relative age effect: implications for effective practice. *Journal of Sports Sciences*, *34*(12), 1124–1131. https://doi.org/10.1080/02640414.2015.1093647

Bailey, R., Cope, E. J., & Pearce, G. (2013). Why do children take part in, and remain involved in sport? A literature review and discussion of implications for sports coaches. *International Journal of Coaching Science*, *7*(1), 56–75. http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=s3h&AN=85448465&site=eds-live&scope=site&custid=s1123095

Benjamin, H. J., & Glow, K. M. (2003). Strength training for children and adolescents. *The Physician and Sportsmedicine*, *31*(9), 19–26.

Blagrove, R. C., Bruinvels, G., & Read, P. (2017). Early sport specialization and intensive training in adolescent female athletes: Risks and recommendations. *Strength and Conditioning Journal*, *39*(5), 14–23. https://doi.org/10.1519/SSC.0000000000000315

Bourdon, P. C., Cardinale, M., Murray, A., Gastin, P., Kellmann, M., Varley, M. C., Gabbett, T. J., Coutts, A. J., Burgess, D. J., Gregson, W., & Cable, N. T. (2017). Monitoring

athlete training loads: Consensus statement. *International Journal of Sports Physiology and Performance*, *12*, 161–170. https://doi.org/10.1123/IJSPP.2017-0208

Cabri, J., Sousa, J. P., Kots, M., & Barreiros, J. (2009). Golf-related injuries: A systematic review. In *European Journal of Sport Science* (Vol. 9, Issue 6, pp. 353–366). Taylor and Francis Ltd. https://doi.org/10.1080/17461390903009141

Coughlan, D., Taylor, M. J. D., Wayland, W., Brooks, D., & Jackson, J. (2020). The effect of a 12-week strength and conditioning programme on youth golf performance. *International Journal of Golf Science*, *8*(1).

Dai, B., Herman, D., Liu, H., Garrett, W. E., & Yu, B. (2012). Prevention of ACL injury, part I: Injury characteristics, risk factors, and loading mechanism. *Research in Sports Medicine*, *20*(3–4), 180–197. https://doi.org/10.1080/15438627.2012.680990

Dix, J., Marsh, S., Dingenen, B., & Malliaras, P. (2019). The relationship between hip muscle strength and dynamic knee valgus in asymptomatic females: A systematic review. *Physical Therapy in Sport*, *37*, 197–209. https://doi.org/10.1016/j.ptsp.2018.05.015

Dvorak, J., Junge, A., Chomiak, J., Graf-Baumann, T., Peterson, L., Rösch, D., & Hodgson, R. (2000). Risk factor analysis for injuries in football players: Possibilities for a prevention program. *American Journal of Sports Medicine*, *28*(S5). https://doi.org/10.1177/28.suppl_5.s-69

Ebaugh, D. D., McClure, P. W., & Karduna, A. R. (2006). Scapulothoracic and glenohumeral kinematics following an external rotation fatigue protocol. *Journal of Orthopaedic and Sports Physical Therapy*, *36*(8), 557–571. https://doi.org/10.2519/jospt.2006.2189

Edwards, N., Dickin, C., & Wang, H. (2020). Low Back Pain and Golf: A Review of Biomechanical Risk Factors. *Sports Medicine and Health Science*. https://doi.org/10.1016/j.smhs.2020.03.002

Ehlert, A. (2020). The effects of strength and conditioning interventions on golf performance:

A systematic review. *Journal of Sports Sciences*, *38*(23), 2720–2731. https://doi.org/10.1080/02640414.2020.1796470

Faigenbaum, A.D., Kraemer, W. J., Blimkie, C. J., Jeffreys, I., Micheli, L. J., Nitka, M., & Rowland, T. W. (2009). Youth Resistance Training: Updated Position Statement Paper From the National Strength and Conditioning Association. *Journal of Strength and Conditioning Research*, *23*(S5), S60–S79.

Faigenbaum, Avery D., & McFarland, J. E. (2016). Resistance training for kids: Right from the Start. *ACSM's Health and Fitness Journal*, *20*(5), 16–22. https://doi.org/10.1249/FIT.0000000000000236

Falk, B., & Dotan, R. (2008). Children's thermoregulation during exercise in the heat - A revisit. *Applied Physiology, Nutrition and Metabolism*, *33*(2), 420–427. https://doi.org/10.1139/H07-185

Grandjean, A. C., & Grandjean, N. R. (2007). Dehydration and cognitive performance. *Journal of the American College of Nutrition*, *26*(S5), 549S-554S.

Hall, R., Foss, K. B., Hewett, T. E., & Myer, G. D. (2015). Sport specialization's association with an increased risk of developing anterior knee pain in adolescent female athletes. *Journal of Sport Rehabilitation*, *24*(1), 31–35. https://doi.org/10.1123/jsr.2013-0101

Hayman, R., Polman, R., & Taylor, J. (2012). The validity of retrospective recall in assessing practice regimes in golf. *International Journal of Sport and Exercise Psychology*, *10*(4), 329–337. https://doi.org/10.1080/1612197X.2012.705511

HSBC. (2020). *State of Play 2020: HSBC Golf Report*.

Jayanthi, N. A., Labella, C. R., Fischer, D., Pasulka, J., & Dugas, L. R. (2015). Sports-specialized intensive training and the risk of injury in young athletes: A clinical case-control study. *American Journal of Sports Medicine*, *43*(4), 794–801. https://doi.org/10.1177/0363546514567298

Lambourne, K., & Tomporowski, P. (2010). The effect of exercise-induced arousal on cognitive task performance : A meta-regression analysis. *Brain Research*, *1341*, 12–24. https://doi.org/10.1016/j.brainres.2010.03.091

Langdown, B. L. (2015). *Movement Variability and Strength and Conditioning in Golf* [University of Birmingham]. https://etheses.bham.ac.uk//id/eprint/6164/

Langdown, B. L., Burnett, S., Jones, N., & Coughlan, D. (2018). Practice And Tournament Volumes Of Young Golfers In Regional And National Squads. *World Scientific Congress of Golf*. http://oro.open.ac.uk/id/eprint/55982

Lloyd, R.S., Cronin, J. B., Faigenbaum, A. D., Haff, G. G., Howard, R., Kraemer, W. J., Micheli, L. J., Myer, G. D., & Oliver, J. L. (2016). National Strength and Conditioning Association Position Statement on Long-Term Athletic Development. *Journal of Strength and Conditioning Research*, *30*(6), 1491–1509. https://doi.org/10.1519/JSC.0000000000001387

Lloyd, R.S., Faigenbaum, A. D., Stone, M. H., Oliver, J. L., Jeffreys, I., Moody, J. A., Brewer, C., Pierce, K. C., Mccambridge, T. M., Howard, R., Herrington, L., Hainline, B., Micheli, L. J., Jaques, R., Kraemer, W. J., Mcbride, M. G., Best, T. M., Chu, D. A., Alvar, B. A., & Myer, G. D. (2014). Position statement on youth resistance training: The 2014 International Consensus. *British Journal of Sports Medicine*, *48*, 498–505. https://doi.org/10.1136/bjsports-2013-092952

Lloyd, R.S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength and Conditioning Journal*, *34*(3), 61–72.

Lloyd, R.S., Oliver, J. L., Faigenbaum, A. D., Myer, G. D., & De Ste Croix, M. A. (2014). Chronological age vs. biological maturation: Implications for exercise programming in youth. *The Journal of Strength & Conditioning Research*, *28*(5), 1454–1464. https://doi.org/doi: 10.1519/JSC.0000000000000391

Lloyd, Rhodri S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength and Conditioning Journal*, *34*(3), 61–72. https://doi.org/10.1519/SSC.0b013e31825760ea

Magee, P. J., Gallagher, A. M., & McCormack, J. M. (2017). High prevalence of dehydration and inadequate nutritional knowledge among university and club level athletes. *International Journal of Sport Nutrition and Exercise Metabolism*, *27*(2), 158–168. https://doi.org/10.1123/ijsnem.2016-0053

Malina, R. M., Cumming, S. P., Morano, P. J., Barron, M., & Miller, S. J. (2005). Maturity status of youth football players: A noninvasive estimate. *Medicine and Science in Sports and Exercise*, *37*(6), 1044–1052. https://doi.org/10.1249/01.mss.0000171622.45134.cb

Malina, R. M., Kozieł, S. M., Králik, M., Chrzanowska, M., & Suder, A. (2020). Prediction of maturity offset and age at peak height velocity in a longitudinal series of boys and girls. *American Journal of Human Biology*, *November*, 1–15. https://doi.org/10.1002/ajhb.23551

Mavilidi, M. F., Okely, A. D., Chandler, P., & Paas, F. (2016). Infusing Physical Activities Into the Classroom: Effects on Preschool Children's Geography Learning. *Mind, Brain, and Education*, *10*(4), 256–263. https://doi.org/10.1111/mbe.12131

McCarthy, N., Collins, D., & Court, D. (2016). Start hard, finish better: Further evidence for the reversal of the RAE advantage. *Journal of Sports Sciences*, *34*(15), 1461–1465. https://doi.org/10.1080/02640414.2015.1119297

Meira, E. P., & Brumitt, J. (2010). Minimizing injuries and enhancing performance in golf through training programs. *Sports Health*, *2*(4), 337–344. https://doi.org/10.1177/1941738110365129

Mills, K., Baker, D., Pacey, V., Wollin, M., & Drew, M. K. (2017). What is the most accurate

and reliable methodological approach for predicting peak height velocity in adolescents? A systematic review. *Journal of Science and Medicine in Sport*, *20*(6), 572–577. https://doi.org/10.1016/j.jsams.2016.10.012

Murray, E., Birley, E., Twycross-Lewis, R., & Morrissey, D. (2009). The relationship between hip rotation range of movement and low back pain prevalence in amateur golfers: An observational study. *Physical Therapy in Sport*, *10*(4), 131–135. https://doi.org/10.1016/j.ptsp.2009.08.002

Myer, G. D., Faigenbaum, A. D., Chu, D. A., Falkel, J., Ford, K. R., Best, T. M., & Hewett, T. E. (2011). Integrative training for children and adolescents: techniques and practices for reducing sports-related injuries and enhancing athletic performance. *The Physician and Sportsmedicine*, *39*(1), 74–84. https://doi.org/10.3810/psm.2011.02.1864

Myer, G. D., Jayanthi, N., Difiori, J. P., Faigenbaum, A. D., Kiefer, A. W., Logerstedt, D., & Micheli, L. J. (2015). Sport Specialization, Part I: Does Early Sports Specialization Increase Negative Outcomes and Reduce the Opportunity for Success in Young Athletes? *Sports Health*, *7*(5), 437–442. https://doi.org/10.1177/1941738115598747

Myer, G. D., Lloyd, R. S., Brent, J. L., & Faigenbaum, A. D. (2013). How young is too young to start training? *ACSM's Health and Fitness Journal*, *17*(5), 14–23. https://doi.org/10.1249/FIT.0b013e3182a06c59

Panoutsakopoulos, V., Kotzamanidou, M. C., Papaiakovou, G., & Kollias, I. A. (2021). The Ankle Joint Range of Motion and Its Effect on Squat Jump Performance with and without Arm Swing in Adolescent Female Volleyball Players. *Journal of Functional Morphology and Kinesiology*, *6*(1), 14. https://doi.org/10.3390/jfmk6010014

Peitz, M., Behringer, M., & Granacher, U. (2018). Correction: A systematic review on the effects of resistance and plyometric training on physical fitness in youth- What do comparative studies tell us? *PLOS ONE*, *13*(11), e0207641. https://doi.org/10.1371/journal.pone.0207641

Penha, P. J., João, S. M. A., Casarotto, R. A., Amino, C. J., & Penteado, D. C. (2005). Postural assessment of girls between 7 and 10 years of age. *Clinics (São Paulo, Brazil)*, *60*(1), 9–16. https://doi.org/10.1590/S1807-59322005000100004

Philippaerts, R. M., Vaeyens, R., Janssens, M., Van Renterghem, B., Matthys, D., Craen, R., Bourgois, J., Vrijens, J., Beunen, G., & Malina, R. M. (2006). The relationship between peak height velocity and physical performance in youth soccer players. *Journal of Sports Sciences*, *24*(3), 221–230. https://doi.org/10.1080/02640410500189371

Read, P. J., Oliver, J. L., De Ste Croix, M. B. A., Myer, G. D., & Lloyd, R. S. (2016). The scientific foundations and associated injury risks of early soccer specialisation. *Journal of Sports Sciences*, *34*(24), 2295–2302. https://doi.org/10.1080/02640414.2016.1173221

Rechel, J. A., Yard, E. E., & Comstock, R. D. (2008). An epidemiologic comparison of high school sports injuries sustained in practice and competition. *Journal of Athletic Training*, *43*(2), 197–204. https://doi.org/10.4085/1062-6050-43.2.197

Rowland, T. (2008). Thermoregulation during exercise in the heat in children: Old concepts revisited. *Journal of Applied Physiology*, *105*(2), 718–724. https://doi.org/10.1152/japplphysiol.01196.2007

Sherar, L. B., Mirwald, R. L., Baxter-Jones, A. D. G., & Thomis, M. (2015). Prediction of adult height using maturity- based camulative height velocity curves. *Journal of Sports Sciences*, *14*(4), 1–9.

Smith, C. J., Lubans, D. R., & Callister, R. (2014). The Effects of Resistance Training on Junior Golfers' Strength and On-Course Performance. *International Journal of Golf Science*, *3*(2), 128–144. https://doi.org/10.1123/ijgs.2014-0023

Smith, M. F., Newell, A. J., & Baker, M. R. (2012). Effect of acute mild dehydration on cognitive-motor performance in golf. *The Journal of Strength & Conditioning Research*,

*26*(11), 3075–3080.

Struyf, F., Nijs, J., Horsten, S., Mottram, S., Truijen, S., & Meeusen, R. (2011). Scapular positioning and motor control in children and adults: A laboratory study using clinical measures. *Manual Therapy*, *16*(2), 155–160. https://doi.org/10.1016/j.math.2010.09.002

Suchomel, T. J., Nimphius, S., & Stone, M. H. (2016). The Importance of Muscular Strength in Athletic Performance. *Sports Medicine*, *46*(10), 1419–1449. https://doi.org/10.1007/s40279-016-0486-0

Tanner, J. (1962). *Growth at Adolescence* (2nd ed.). Blackwell Publishing Ltd.

The R&A & The EGA. (2019). *European Golf Participation*. https://www.randa.org/en/theranda/initiatives/golf-research

US Kids Golf. (n.d.). *Tournaments*. Retrieved October 19, 2020, from https://foundation.uskidsgolf.com/tournaments

VandenBerg, C., Crawford, E. A., Sibilsky Enselman, E., Robbins, C. B., Wojtys, E. M., & Bedi, A. (2017). Restricted Hip Rotation Is Correlated With an Increased Risk for Anterior Cruciate Ligament Injury. *Arthroscopy - Journal of Arthroscopic and Related Surgery*, *33*(2), 317–325. https://doi.org/10.1016/j.arthro.2016.08.014

Wasser, J. G., Tripp, B., Bruner, M. L., Bailey, D. R., Leitz, R. S., Zaremski, J. L., & Vincent, H. K. (2020). Volleyball-related injuries in adolescent female players: an initial report. *Physician and Sportsmedicine*, 1–8. Advance online publication https://doi.org/10.1080/00913847.2020.1826284

Wells, J. E. T., Charalambous, L. H., Mitchell, A. C. S., Coughlan, D., Brearley, S. L., Hawkes, R. A., Murray, A. D., Hillman, R. G., & Fletcher, I. M. (2019). Relationships between Challenge Tour golfers' clubhead velocity and force producing capabilities during a countermovement jump and isometric mid-thigh pull. *Journal of Sports*

*Sciences*, *37*(12), 1381–1386. https://doi.org/10.1080/02640414.2018.1559972

Westbrook, A. E., Taylor, J. B., Nguyen, A. D., Paterno, M. V., & Ford, K. R. (2020). Effects of maturation on knee biomechanics during cutting and landing in young female soccer players. *PLoS ONE*, *15*(5), 1–11. https://doi.org/10.1371/journal.pone.0233701

Williams, S. B., Gastin, P. B., Saw, A. E., & Robertson, S. (2018). Development of a golf-specific load monitoring tool: Content validity and feasibility. *European Journal of Sport Science*, *18*(4), 458–472. https://doi.org/10.1080/17461391.2018.1434239

Wittbrodt, M. T., & Millard-Stafford, M. (2018). Dehydration Impairs Cognitive Performance: A Meta-analysis. *Medicine and Science in Sports and Exercise*, *50*(11), 2360–2368. https://doi.org/10.1249/MSS.0000000000001682