



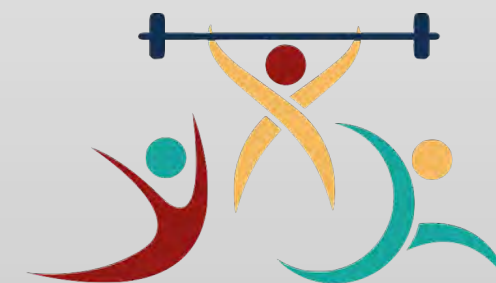
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IDENTIFICATION vs DEVELOPMENT





An Update on Secular Trends in Physical Fitness of Children and Adolescents from 1972 to 2015: A Systematic Review

Thea Fühner¹ · Reinhold Kliegl¹ · Fabian Arntz¹ · Susi Kriemler² · Urs Granacher¹

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Abstract

Background There is evidence that physical fitness of children and adolescents (particularly cardiorespiratory endurance) has declined globally over the past decades. Ever since the first reports on negative trends in physical fitness, efforts have been undertaken by for instance the World Health Organization (WHO) to promote physical activity and fitness in children and adolescents. Therefore, it is timely to re-analyze the literature to examine whether previous reports on secular declines in physical fitness are still detectable or whether they need to be updated.

Objectives The objective of this systematic review is to provide an ‘update’ on secular trends in selected components of physical fitness (i.e., cardiorespiratory endurance, relative muscle strength, proxies of muscle power, speed) in children and adolescents aged 6–18 years.

Data Sources A systematic computerized literature search was conducted in the electronic databases PubMed and Web of Science to locate studies that explicitly reported secular trends in physical fitness of children and adolescents.

Study Eligibility Criteria Studies were included in this systematic review if they examined secular trends between at least two time points across a minimum of 5 years. In addition, they had to document secular trends in any measure of cardiorespiratory endurance, relative muscle strength, proxies of muscle power or speed in apparently healthy children and adolescents aged 6–18 years.

Study Appraisal and Synthesis Methods The included studies were coded for the following criteria: nation, physical fitness component (cardiorespiratory endurance, relative muscle strength, proxies of muscle power, speed), chronological age, sex (boys vs. girls), and year of assessment. Scores were standardized (i.e., converted to z scores) with sample-weighted means and standard deviations, pooled across sex and year of assessment within cells defined by study, test, and children’s age.

Results The original search identified 524 hits. In the end, 22 studies met the inclusion criteria for review. The observation period was between 1972 and 2015. Fifteen of the 22 studies used tests for cardiorespiratory endurance, eight for relative muscle strength, eleven for proxies of muscle power, and eight for speed. Measures of cardiorespiratory endurance exhibited a large initial increase and an equally large subsequent decrease, but the decrease appears to have reached a floor for all children between 2010 and 2015. Measures of relative muscle strength showed a general trend towards a small increase. Measures of proxies of muscle power indicated an overall small negative quadratic trend. For measures of speed, a small-to-medium increase was observed in recent years.

Limitations Biological maturity was not considered in the analysis because biological maturity was not reported in most included studies.

Conclusions Negative secular trends were particularly found for cardiorespiratory endurance between 1986 and 2010–12, irrespective of sex. Relative muscle strength and speed showed small increases while proxies of muscle power declined. Although the negative trend in cardiorespiratory endurance appears to have reached a floor in recent years, because of its association with markers of health, we recommend further initiatives in PA and fitness promotion for children and adolescents. More specifically, public health efforts should focus on exercise that increases cardiorespiratory endurance to prevent adverse health effects (i.e., overweight and obesity) and muscle strength to lay a foundation for motor skill learning.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s40279-020-01373-x>) contains supplementary material, which is available to authorized users.

Extended author information available on the last page of the article

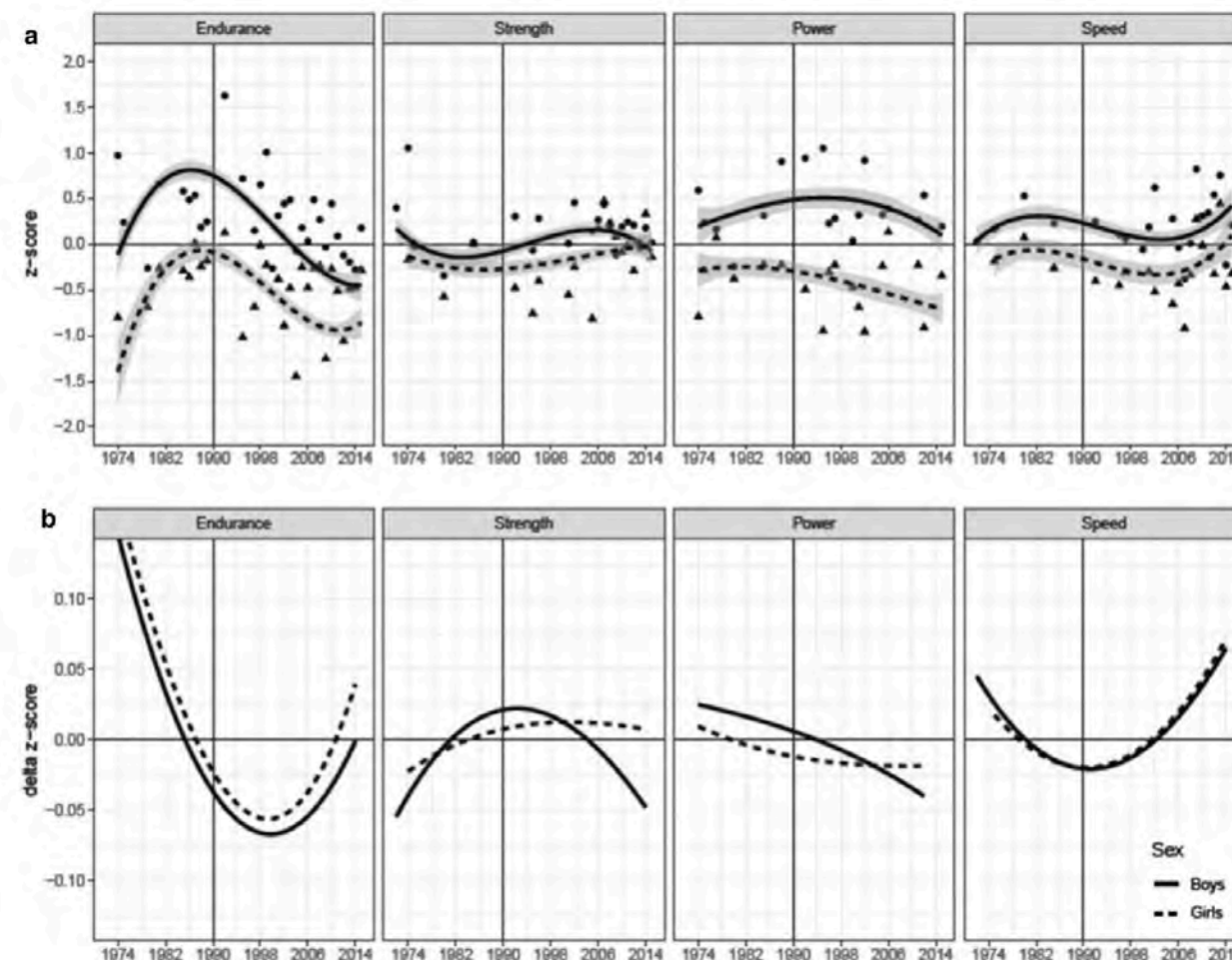


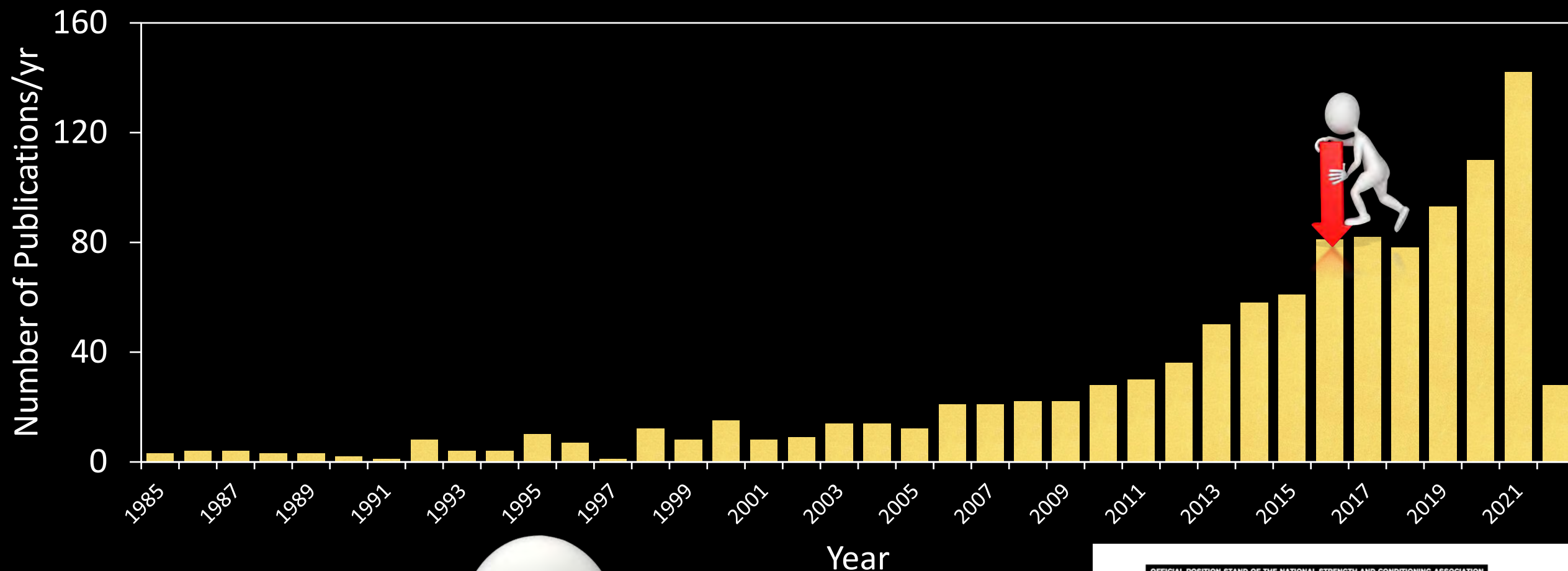
Fig. 2 **a** Secular trends for cardiorespiratory endurance, relative muscle strength, proxies of muscle power, and speed for standardized scores. Positive scores indicate better physical fitness in units of the standard normal distribution (z scores) relative to a grand mean of zero estimated for the year 1990. Dots represent the observed study means; the line is a third-order polynomial regression based on partial effects predicted from data and linear mixed model parameters

(see Table 4); shaded areas represent 95% confidence intervals for the regression lines. **b** Numeric approximations of first derivatives (delta z score) of corresponding functions in panel a (i.e., local changes in the direction of the function). Minima and maxima in panel a correspond to zero-crossings in **b**; inflection points in cubic functions in panel a correspond to minima and maxima of first derivatives in **b**



RESEARCH UPDATE

PubMed search “long-term” AND “athlet*” AND “development”, 1985-2022



Rhodri Lloyd, PhD, CSCS, NSCA, Sylvia Moeskops, PhD, CSCS and Ja
Long-term Athletic Development in Action

OFFICIAL POSITION STAND OF THE NATIONAL STRENGTH AND CONDITIONING ASSOCIATION

NATIONAL STRENGTH AND CONDITIONING ASSOCIATION POSITION STATEMENT ON LONG-TERM ATHLETIC DEVELOPMENT

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ABSTRACT

Lloyd, RS, Cronin, JB, Faigenbaum, AD, Haff, GG, Howard, R, Kraemer, WJ, Michell, LJ, Myer, GD, and Oliver, JL. National Strength and Conditioning Association position statement on long-term athletic development. *J Strength Cond Res* 30(6): 1491–1509, 2016—There has recently been a growing interest in long-term athletic development for youth. Because of their unique physical, psychological, and social differences, children and adolescents should engage in appropriately prescribed exercise programs that promote physical development to prevent injury and enhance fitness behaviors that can be retained later in life. Irrespective of whether a child is involved in organized sport or engages in recreational physical activity, there remains a need to adopt a structured, logical, and evidence-based approach to the long-term development of athleticism. This is of particular importance considering the alarmingly high number of youth who fail to meet global physical activity recommendations and consequently present with negative health profiles. However, appropriate exercise prescription is also crucial for those young athletes who are physically underprepared and at risk of overuse injury because of high volumes of competition and an absence of preparatory conditioning. Whether the child accumulates insufficient or excessive amounts of exercise, or falls somewhere between these opposing ends of the spectrum, it is generally accepted that

the young bodies of modern day youth are often ill-prepared to tolerate the rigors of sports or physical activity. All youth should engage in regular physical activity and thus should be viewed as “athletes” and afforded the opportunity to enhance athleticism in an individualized, holistic, and child-centered manner. Because of emerging interest in long-term athletic development, an authorship team was tasked on behalf of the National Strength and Conditioning Association (NSCA) to critically synthesize existing literature and current practices within the field and to compose a relevant position statement. This document was subsequently reviewed and formally ratified by the NSCA Board of Directors. A list of 10 pillars of successful long-term athletic development are presented, which summarize the key recommendations detailed within the position statement. With these pillars in place, it is believed that the NSCA can (a) help foster a more unified and holistic approach to long-term athletic development, (b) promote the benefits of a lifetime of healthy physical activity, and (c) prevent and/or minimize injuries from sports participation for all boys and girls.

KEY WORDS long-term athlete development, youth physical development, children, adolescents, health, fitness

OPERATIONAL TERMS

Throughout this position statement, the following operational terms are defined as given below:

- **Athleticism** is the ability to repeatedly perform a range of movements with precision and confidence in a variety of environments, which require competent levels of motor skills, strength, power, speed, agility, balance, coordination, and endurance.

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30(6):1491–1509
Journal of Strength and Conditioning Research
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The 10 Pillars of Successful Long-term Athletic Development

National Strength and Conditioning Association | Lloyd et al. (2016), JSCR, 30(6), 1491-1509



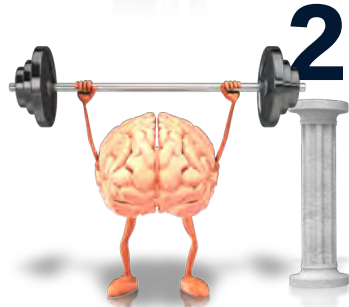
1

LTAD pathways should accommodate for the highly individualised and non-linear nature of the growth and development of youth



6

Youth should participate in physical conditioning that helps reduce the risk of injury to ensure their on-going participation in LTAD programmes



2

Youth of all ages, abilities and aspirations should engage in LTAD programmes that promote physical fitness and psychosocial wellbeing



7

LTAD programmes should provide all youth with a range of training modes to enhance both health- and skill-related components of fitness



3

All youth should be encouraged to enhance physical fitness from early childhood, with a primary focus on motor skill/muscle strength development



8

Practitioners should use relevant monitoring and assessment tools as part of a LTAD strategy



4

LTAD pathways should encourage an early sampling approach for youth that promotes and enhances a broad range of motor skills

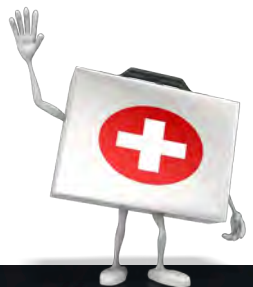


9

Practitioners working with youth should systematically progress and individualise training programmes for successful LTAD

5

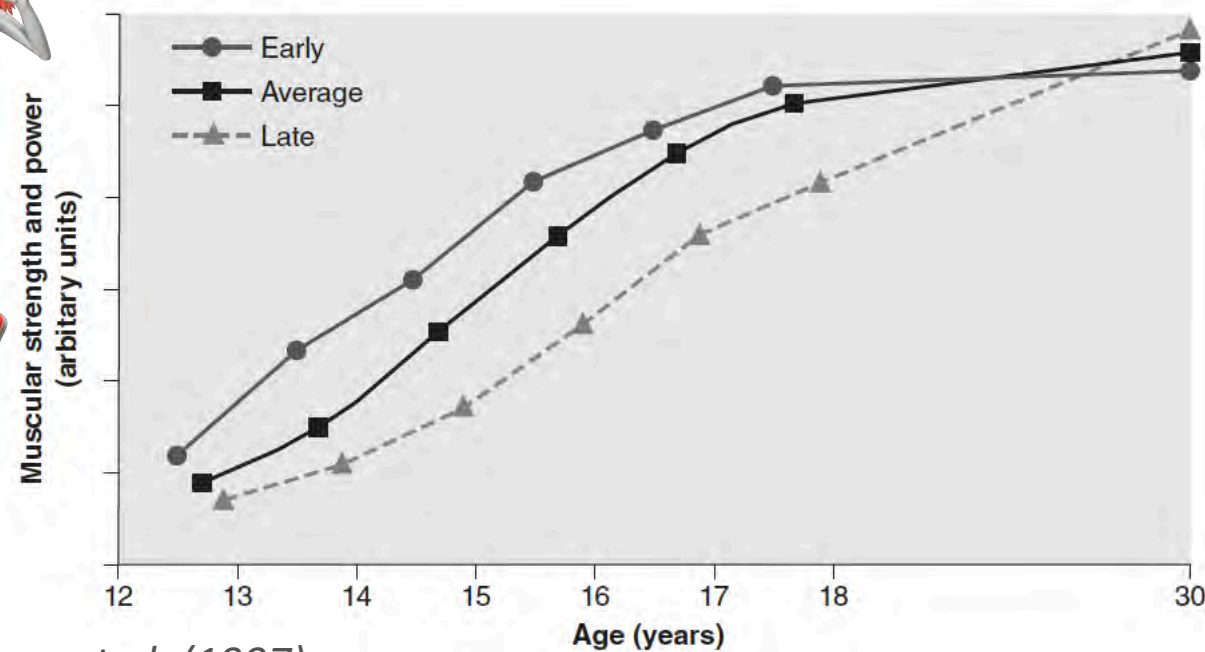
Health and wellbeing of the child should always be the central tenet of LTAD programmes



10

Qualified professionals and sound pedagogical approaches are fundamental to the success of LTAD programmes

FASTER, HIGHER, STRONGER?



Beunen et al. (1997)

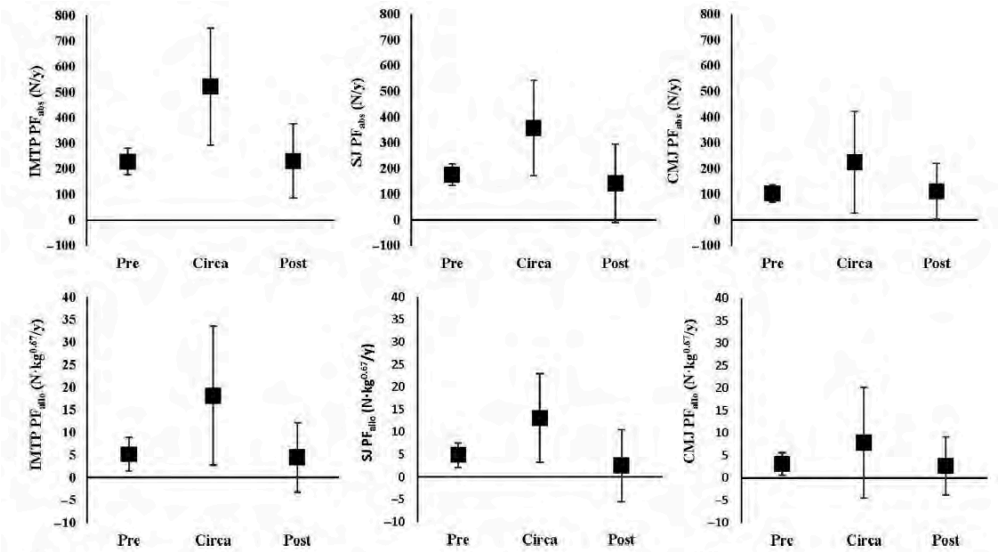
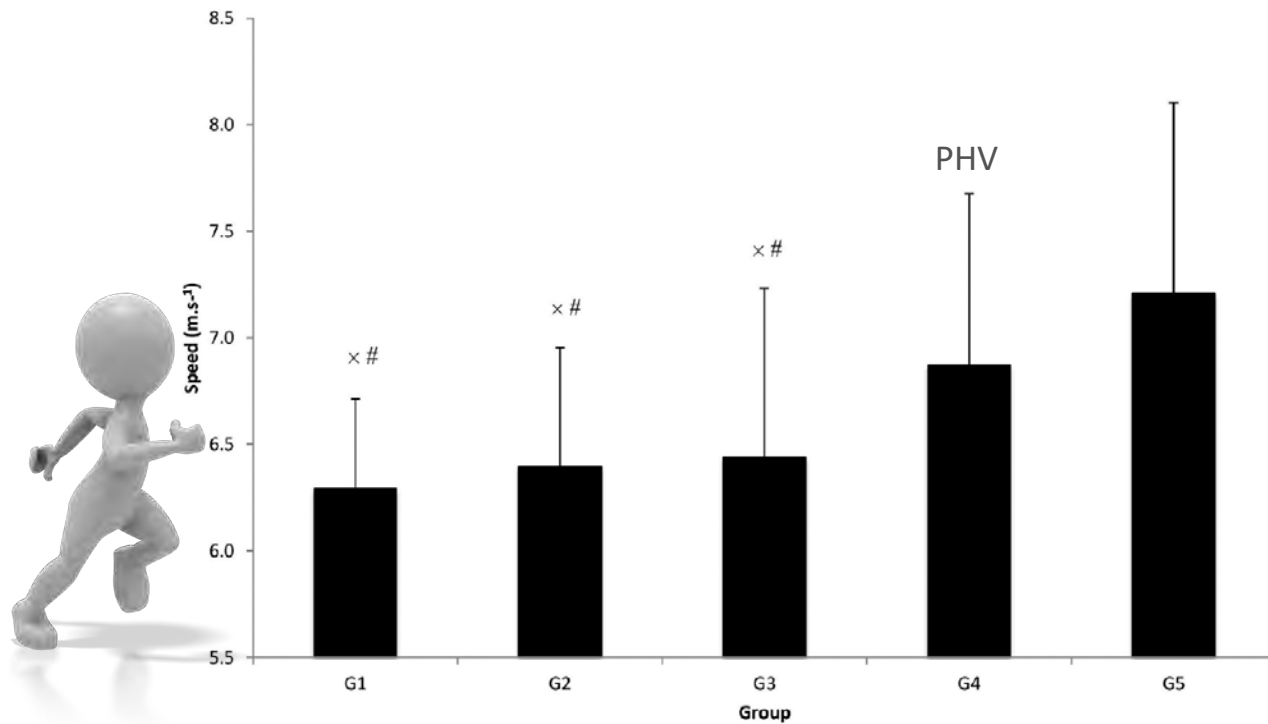
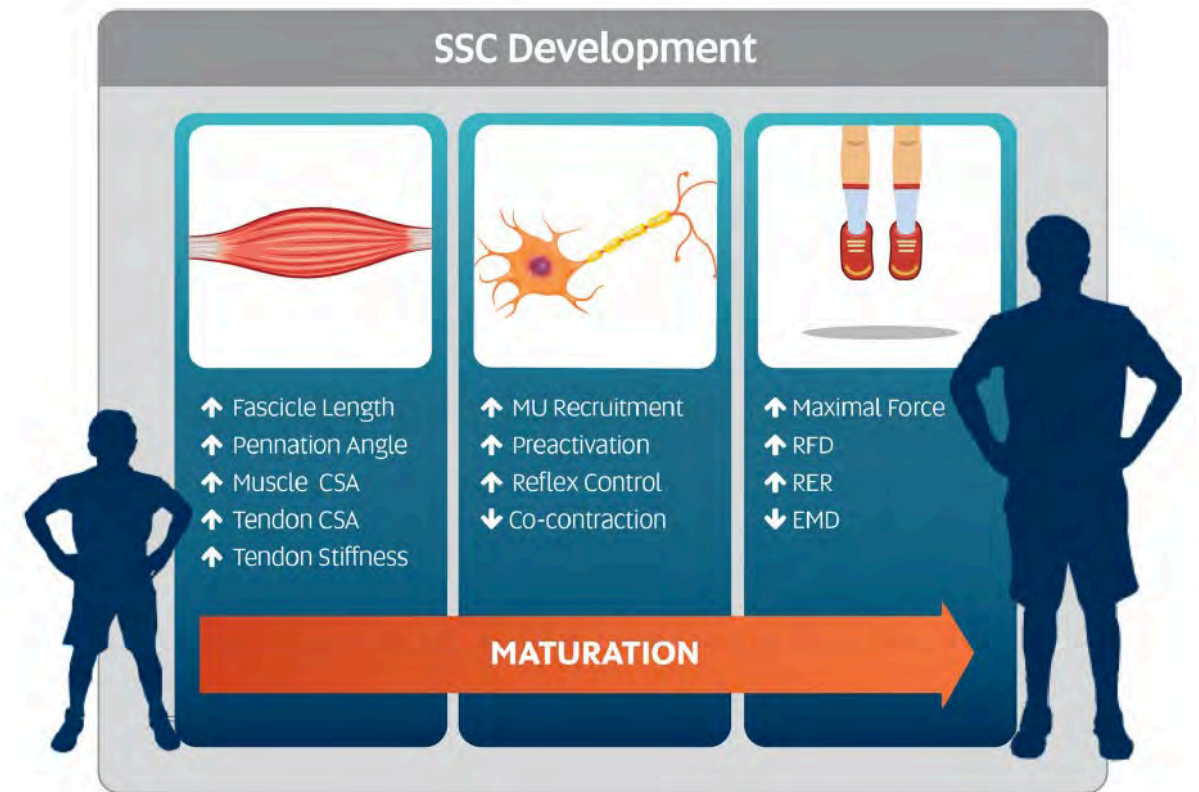


FIGURE 2 Mean rate of change and 95% CI for within-group scores for PF_{abs} and PF_{allo} in the IMTP, SJ, and CMJ tests

Dobbs et al. (2020)



Meyers et al. (2015)



Radnor et al. (2018, 2020), Kumar et al. (2021)

Article

Relationships between Athletic Motor Skill Competencies and Maturity, Sex, Physical Performance, and Psychological Constructs in Boys and Girls

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Abstract: The purpose of this study was to examine the relationships between athletic motor skill competencies (AMSC), maturation, sex, body mass index, physical performance, and psychological constructs (motivation to exercise, physical self-efficacy, and global self-esteem). Two-hundred and twenty-four children aged 11–13 years old were included in the study and sub-divided by sex. The athlete introductory movement screen (AIMS) and tuck jump assessment (TJA) were used to assess AMSC, while standing long jump distance assessed physical performance. Online surveys examined participants' motivation to exercise, physical self-efficacy, and self-esteem. Trivial to moderate strength relationships were evident between AMSC and BMI (boys: $r_s = -0.183$; girls: $r_s = -0.176$), physical performance (boys: $r_s = 0.425$; girls: $r_s = 0.397$), and psychological constructs (boys: $r_s = 0.130$ – 0.336 ; girls: $r_s = 0.030$ – 0.260), with the strength of relationships different between the sexes. Higher levels of AMSC were related to significantly higher levels of physical performance ($d = 0.25$), motivation to exercise ($d = 0.17$), and physical self-efficacy ($d = 0.15$ – 0.19) in both boys and girls. Enhancing AMSC may have mediating effects on levels of physical performance and psychological constructs in school-aged children, which may hold important implications for physical activity levels and the development of physical literacy.

Keywords: physical literacy; strength and conditioning; youth

1. Introduction

The development of muscular strength and movement skills in youth is a key outcome for leading health authorities, long-term athletic development models, and physical education curricula [1–3]. Reduction of chronic diseases, reduced injury risk, improved health and well-being, and longevity in physical activity are all products of improving muscular strength and movement skills in youth [4–9]. Previous research investigating the development of movement skills has focused mainly on fundamental movement skills in youth, which include locomotive, stabilisation, and manipulation skills [6,7,10–14]. Lloyd et al. [15] introduced the concept of athletic motor skill competencies (AMSC) to guide strength and conditioning coaches and physical education teachers in developing young people's athleticism. The AMSC are considered foundational movement skills that underpin athletic movements, providing youth with the skills needed to safely and effectively participate in physical activity with confidence and competence [15,16]. The AMSC incorporate skills such as lower-body bilateral and unilateral movements, upper-body pushing



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Article

The Influence of Maturity Offset, Strength, and Movement Competency on Motor Skill Performance in Adolescent Males

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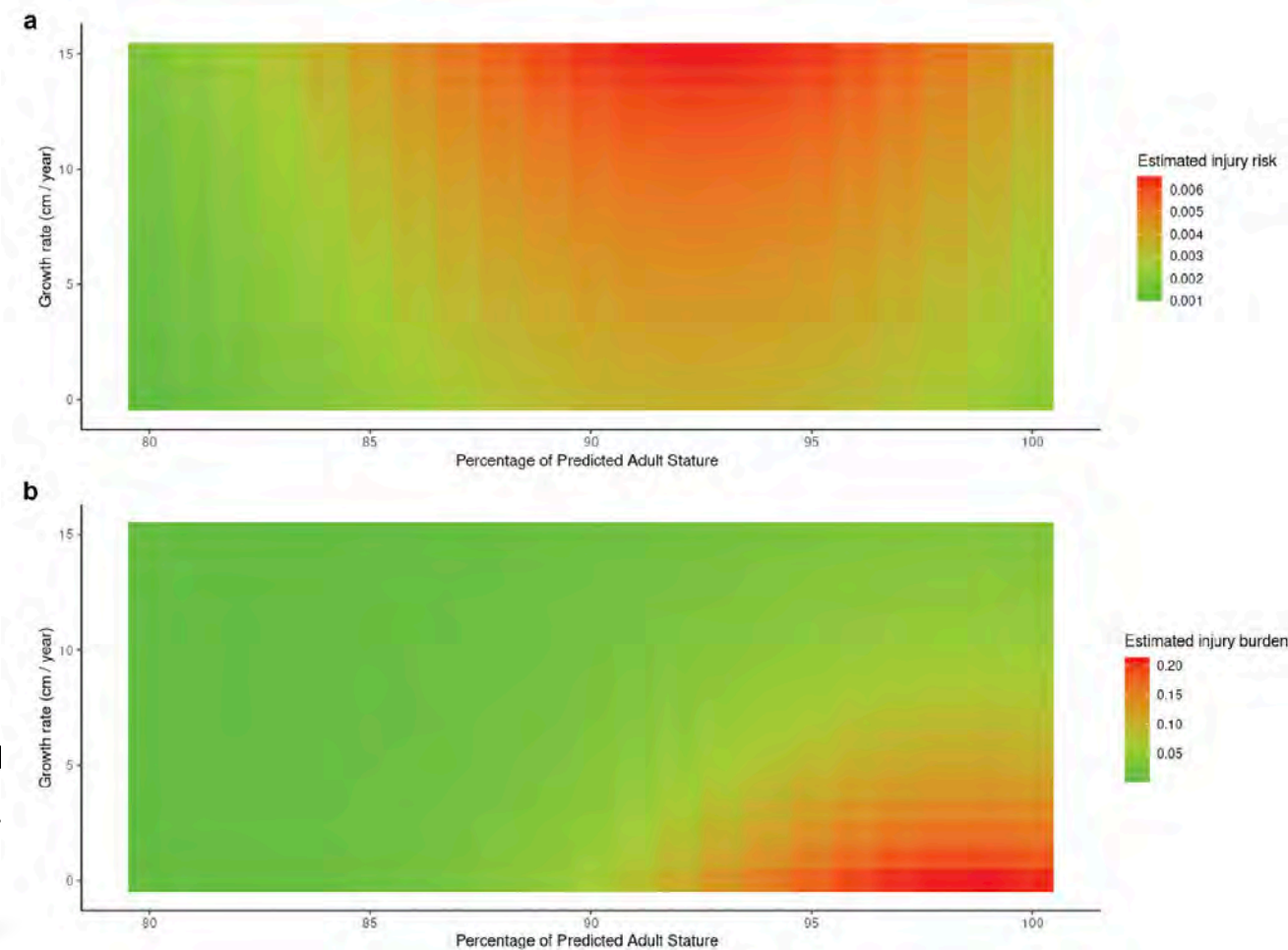
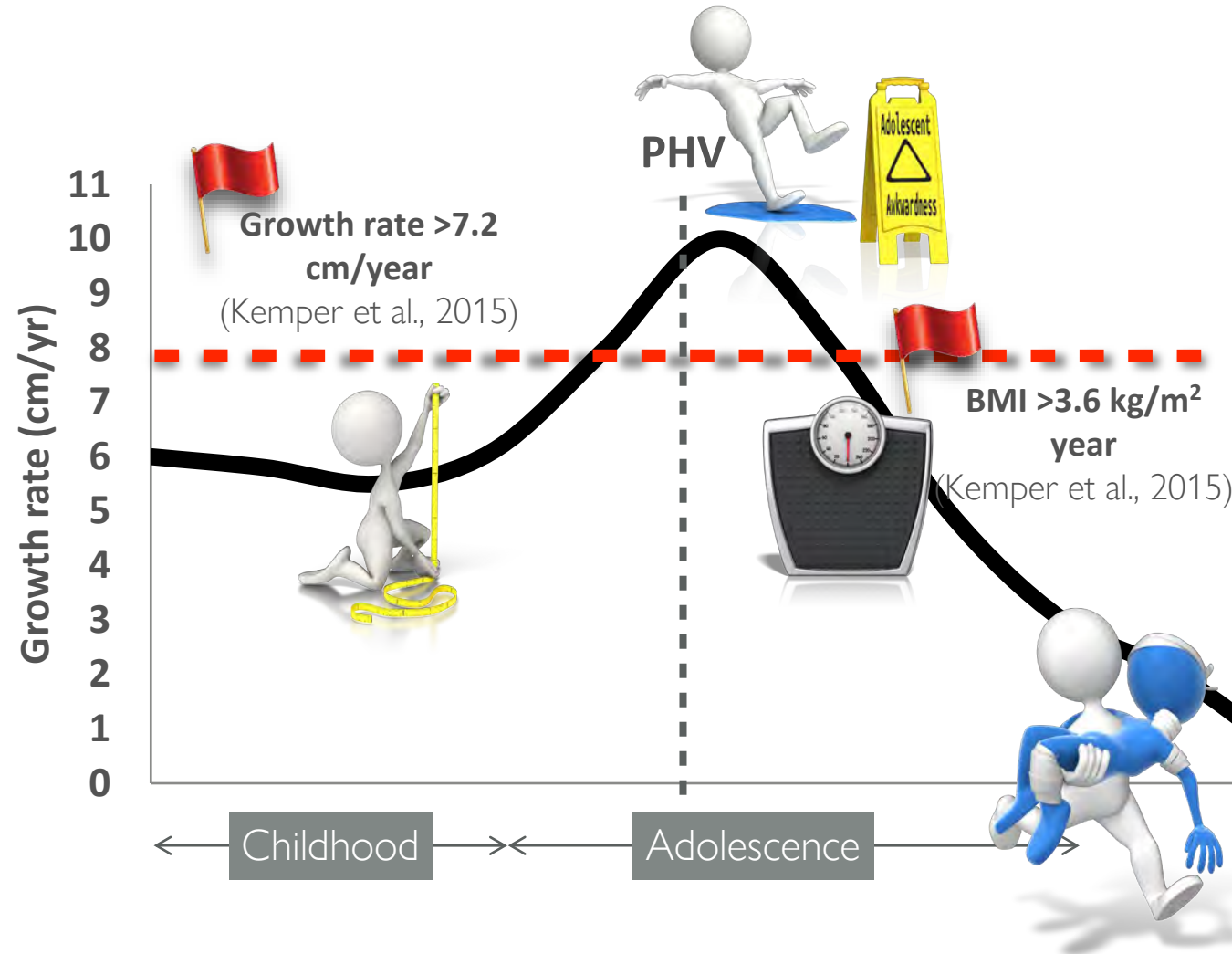


Abstract: This study aimed to examine the extent to which maturity offset, strength, and movement competency influences motor skill performance in adolescent boys. One hundred and eight secondary school boys completed anthropometric and physical testing on two non-consecutive days for the following variables: Maturity offset, isometric mid-thigh pull absolute (IMTP_{ABS}) and relative (IMTP_{REL}) peak force, resistance training skills quotient, 10-, 20-, and 30-m sprint time, countermovement jump height, horizontal jump distance, anaerobic endurance performance, and seated medicine ball throw (SMBT). The IMTP_{REL} displayed significant small to large correlations with all performance variables ($r = 0.27$ – 0.61), whereas maturity offset was significantly correlated with IMTP_{ABS} ($r = 0.69$), sprint ($r = 0.29$ – 0.33), jump ($r = 0.23$ – 0.34), and SMBT ($r = 0.32$). Absolute and relative strength were the strongest predictors of all performance variables and combined with maturity to explain 21%–76% of the variance. Low and average relative strength boys were nearly eight times (odds ratio: 7.80, confidence interval: 1.48–41.12, $p < 0.05$) and nearly four times (odds ratio: 3.86, confidence interval: 0.95–15.59, $p < 0.05$) more likely to be classified as lower competency compared to high relative strength boys. Relative strength has more influence on motor skill performance than maturity when compared with movement competency.

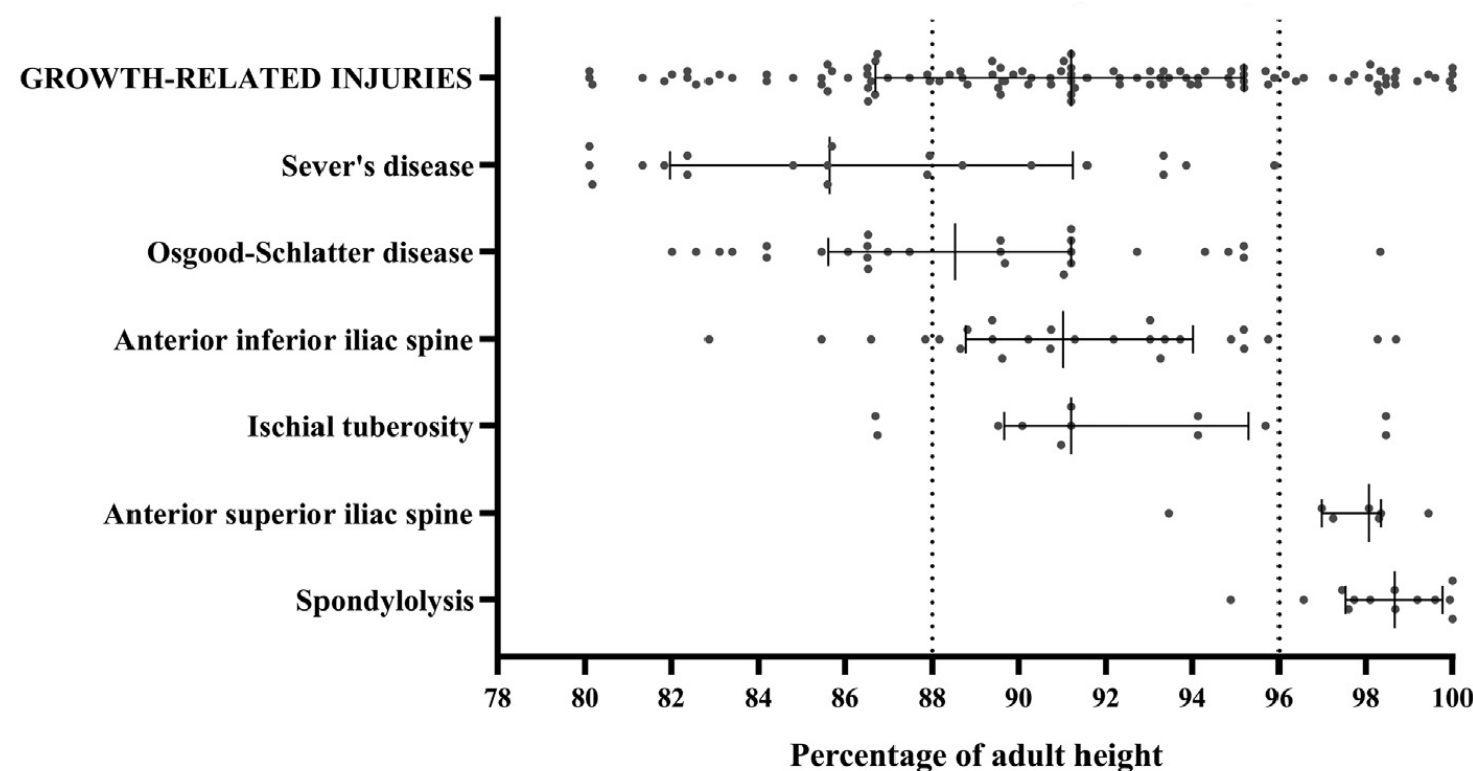
Keywords: youth; isometric mid-thigh pull; sprint; jump; peak height velocity

1. Introduction

Motor skill performance during adolescence is influenced by several factors, such as maturation, strength, and movement competency [1–3], but the relative importance of each of these factors is currently unknown. Biological maturation, which refers to the process of becoming physically mature [4], is accompanied by large increases in androgenic hormones, lean body mass, stature, and neuromuscular coordination in male youth during the adolescent growth spurt [5]. In European males, this growth spurt occurs between 13–14 years old, with boys growing at a maximum rate of over nine centimeters and over eight kilograms per year [6]. Due to the natural increases in height and muscle mass experienced by males during the growth spurt, strength, and performance in motor skill tasks such as running, jumping, sprinting, and throwing have shown the greatest rates of development during this period [6]. Since the onset and rate of change of these biological changes vary between youth, more physically mature boys are often selected for representative teams [7,8] or viewed as



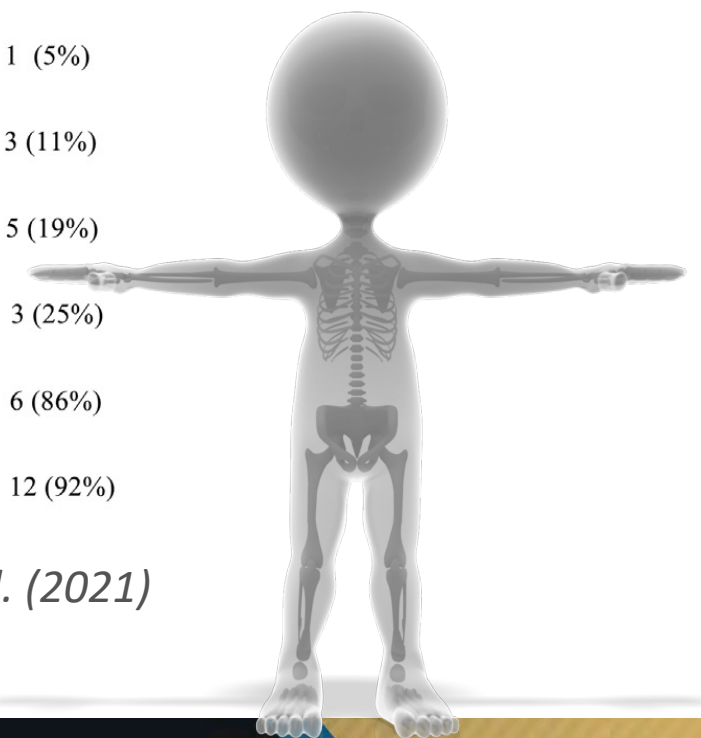
Johnson et al. (2022)



PRE-PHV / CIRCA-PHV / POST-PHV

33 (30%)	47 (42%)	31 (28%)
13 (65%)	6 (30%)	1 (5%)
14 (50%)	11 (39%)	3 (11%)
3 (12%)	18 (69%)	5 (19%)
2 (17%)	7 (58%)	3 (25%)
0 (0%)	1 (14%)	6 (86%)
0 (0%)	1 (8%)	12 (92%)

Monasterio et al. (2021)



Maturity alters drop vertical jump landing force-time profiles but not performance outcomes in adolescent females

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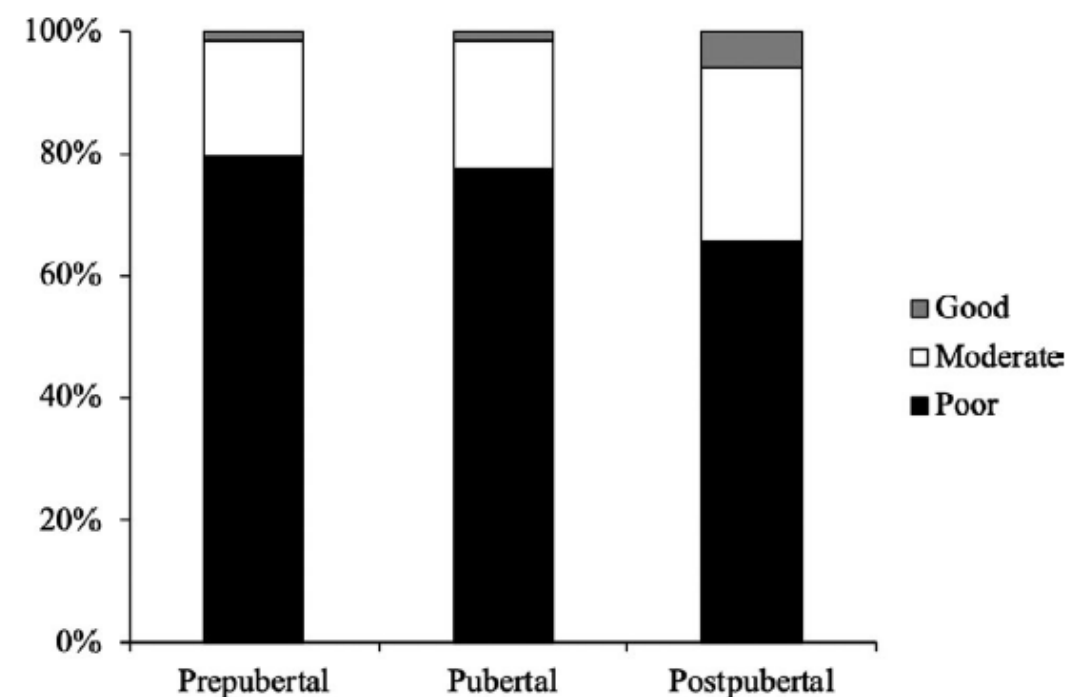
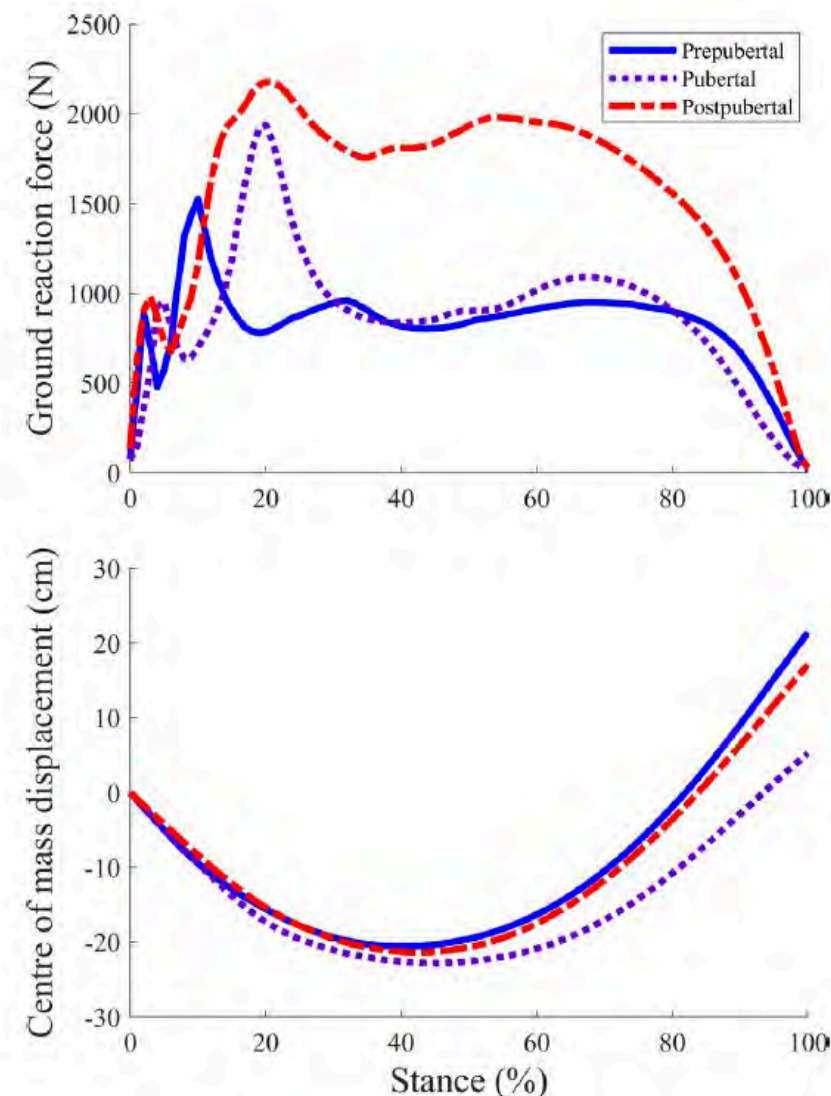
Funding information

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The stretch-shortening cycle (SSC) assists in effective force attenuation upon landing and augments force generation at take-off during a drop vertical jump (DVJ). General performance outcomes such as jump height or peak measures have been used to assess SSC function in youth populations; however, these discrete metrics fail to provide insight into temporal jump-landing characteristics. This study assessed DVJ force-time profiles in 1013 middle and high-school female athletes ($n = 279$ prepubertal, $n = 401$ pubertal, and $n = 333$ postpubertal). Maturity status was determined using the Pubertal Maturation Observation Scale. Ground reaction force data were analyzed to extract a range of variables to characterize force-time profiles. SSC function was categorized as poor, moderate, or good dependent on the presence of an impact peak and spring-like behavior. No differences in jump height or ground contact time were observed between maturity groups ($p > 0.05$). Significant differences in absolute peak landing and take-off force were evident between all maturational statuses ($p < 0.05$). Relative to bodyweight normalized forces, only peak take-off force was significantly different between prepubertal and postpubertal groups ($p < 0.05$; $d = 0.22$). Spring-like behavior showed small improvements from pubertal to postpubertal ($p < 0.05$; $d = 0.25$). Most females displayed poor SSC function at prepubertal (79.6%), pubertal (77.3%), and postpubertal (65.5%) stages of maturity. Large increases in absolute forces occur throughout maturation in female athletes; however, only small maturational differences were found in relative force or spring-like behavior. Consequently, most girls display poor SSC function irrespective of maturity.

KEYWORDS

anterior cruciate ligament, depth jump, growth, maturation, plyometric



LIMITATIONS WITH THE LITERATURE

- 
1. Lack of longitudinal studies
 2. Not accounting for maturation
 3. Reliance on performance metrics



Effects of Resistance Training on Physical Fitness in Healthy Children and Adolescents: An Umbrella Review

Melanie Lesinski¹ · Michael Herz¹ · Alina Schmelcher¹ · Urs Granacher¹ 

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Abstract

Background Over the past decades, an exponential growth has occurred with regards to the number of scientific publications including meta-analyses on youth resistance training (RT). Accordingly, it is timely to summarize findings from meta-analyses in the form of an umbrella review.

Objectives To systematically review and summarize RT on physical fitness in children and adolescents.

Design Systematic umbrella review of meta-analyses.

Data Sources Meta-analyses were identified using PubMed and Cochrane Library.

Eligibility Criteria for Selecting Meta-analyses Meta-analyses on physical fitness in healthy youth (≤ 18 years).

Results Fourteen meta-analyses were included. The subject effect sizes which are important to eliminate on muscle strength, small-to-large effects on muscle power, agility/change-of-direction speed, small-to-large enhancement. There were few consistent moderate strength and muscle power across the included meta-analyses. The methodological quality (AMSTAR2) as well as presentation of results was generally poor. **Conclusion** This umbrella review proved the effectiveness of RT on physical fitness in healthy youth. The effect varies according to the respective outcome measures. Small-to-large effects were found for strength-related outcomes. More research is needed with regards to the effect of RT on muscle power, agility/change-of-direction speed, and sport-specific performance.

1 Introduction

Despite previous misconceptions on the effectiveness and safety of youth resistance training (RT), more recent studies show convincing evidence of RT on marker of performance and health in healthy children and adolescents.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s40279-020-01327-3>) contains supplementary material, which is available to authorized users.

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Muscle strength

Behringer et al. [18]	No plyometric training
Falk et al. [19]	
Lesinski et al. [4]	Only trained boys and girls
Moran et al. [22]	Only girls
Payne et al. [17]	No restrictions

Muscle power

Behringer et al. [16]	No restrictions
Collins et al. [5]	No plyometric training
Lesinski et al. [4]	Only trained boys and girls
Moran et al. [26]	Only trained boys; only plyometric training
Moran et al. [21]	Only girls; only plyometric training
Slimani et al. [23]	Only trained boys and girls; no plyometric or power training

Linear speed

Behringer et al. [16]	No restrictions
Collins et al. [5]	No plyometric training
Lesinski et al. [4]	Only trained boys and girls

Agility/change of direction

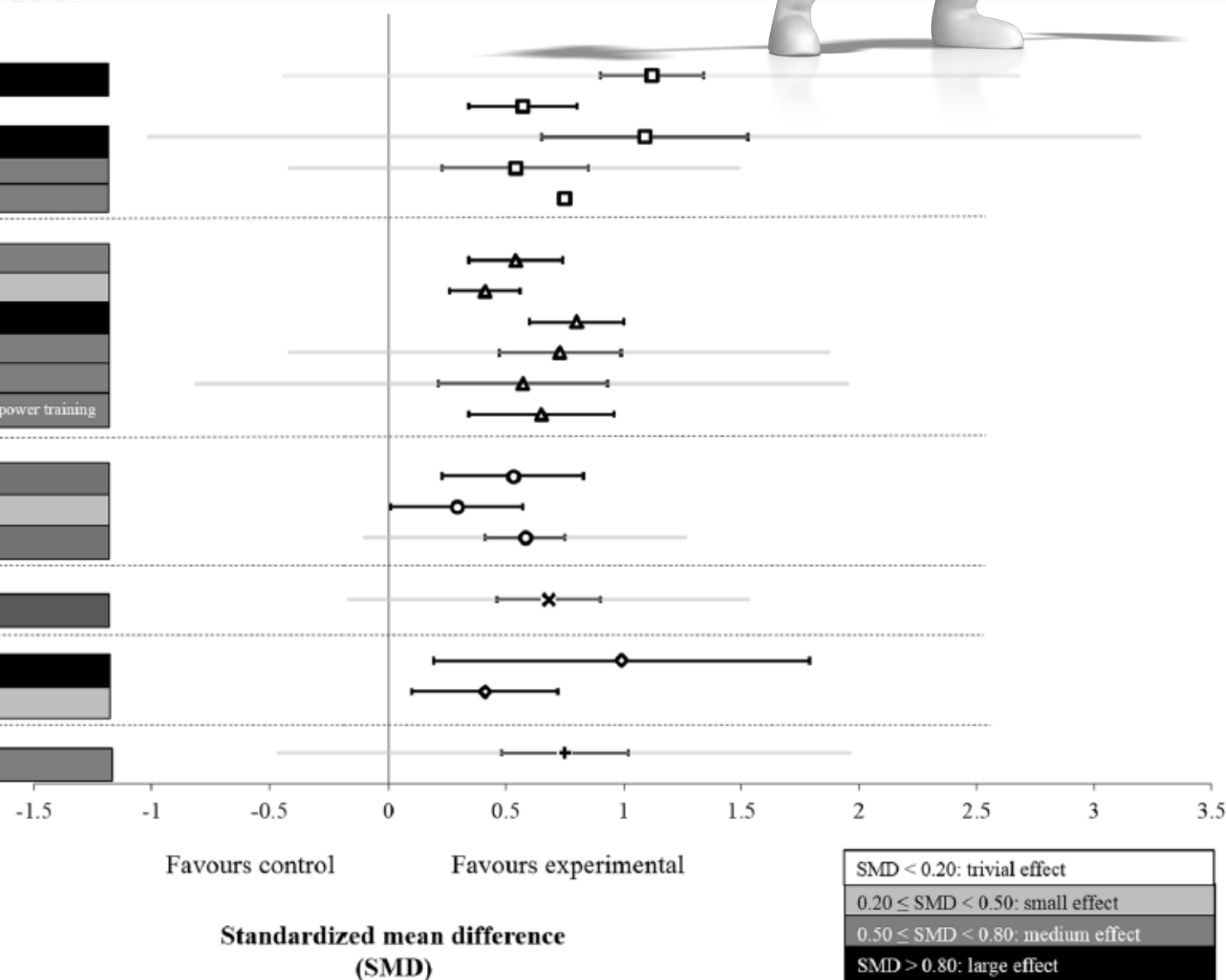
Lesinski et al. [4]	Only trained boys and girls
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Throw

Behringer et al. [16]	No restrictions
Collins et al. [5]	No plyometric training

Sport-specific-performance

Lesinski et al. [4]	Only trained boys and girls
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Effects of Training Frequency During a 6-Month Neuromuscular Training Intervention on Movement Competency, Strength, and Power in Male Youth

Rhodri S. Lloyd, PhD,^{*†‡§} Ian J. Dobbs, PhD,[†] Megan A. Wong, MS,[†] Isabel S. Moore, PhD,[†] and Jon L. Oliver, PhD^{†‡}

Background: Youth populations benefit from neuromuscular training; however, the extent to which training frequency, baseline fitness, and maturity status moderate the response to long-term neuromuscular training in male youth remains unclear.

Hypothesis: Twice-weekly training (G2x) would induce larger improvements in movement competency and strength and power kinetics compared with once-weekly training (G1x). Maturity status and baseline fitness would also moderate the training response in strength and power kinetics.

Study Design: Nonrandomized, repeated-measures design.

Level of Evidence: Level 3

Methods: Ninety-five male athletes of varying maturity status (pre- or post-peak height velocity) were divided into G2x, G1x, or control (CON) groups. Training groups received G2x or G1x for 28 weeks. Back squat assessment (BSA) movement competency and isometric mid-thigh pull (IMTP), squat jump (SJ), and countermovement jump (CMJ) kinetics were measured pre- and postintervention.

Results: The G2x achieved significantly greater adaptations in BSA total score, IMTP allometrically scaled peak force (PF_{allo}), IMTP peak rate-of-force development (PRFD), SJ PF_{allo} and PRFD compared with G1x and CON ($P < 0.05$; $d = 0.3$ – 0.9). Baseline fitness, training frequency and maturity status were significant predictors of IMTP PF_{allo} ($R^2 = 27.5\%$) and PRFD ($R^2 = 42.9\%$), while a combination of training frequency and baseline fitness explained a small amount of variance in SJ PF_{allo} ($R^2 = 12.2\%$) and SJ PRFD ($R^2 = 6.5\%$). There were no significant predictors of CMJ kinetics.

Conclusion: G2x achieved significantly larger improvements in movement competency, isometric strength and concentric jump variables compared with G1x, with the training response greater in those youth with lower baseline fitness and more advanced maturity status.

Clinical Relevance: Exposure to neuromuscular training twice-weekly elicits a greater response than G1x in young male athletes. Practitioners should take maturity status, training frequency, and baseline fitness levels of young male athletes into account when interpreting testing data, as these variables appear to moderate training responsiveness.

Keywords: adolescent; children; resistance training; long-term athletic development; kinetics

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Main Findings

G2x

achieved significantly greater adaptations in BSA total score, IMTP PF_{allo} and PRFD, SJ PF_{allo} and PRFD compared to G1x and CON

IMTP

Baseline fitness, training frequency and maturity status explained ~**28%** ΔPF_{allo} and ~**43%** $\Delta PRFD$

SJ

Training frequency and baseline fitness explained ~**12%** ΔPF_{allo} and ~**7%** $\Delta PRFD$

Key Points



Twice-weekly training achieved significantly larger improvements in movement competency, isometric strength and concentric jump variables compared to once-weekly training



Training response greater in those youth with **higher training frequency**, **lower baseline fitness** and more **advanced maturity status**

Effects of a 10-Month Neuromuscular Training Program on Strength, Power, Speed, and Vault Performance in Young Female Gymnasts

SYLVIA MOESKOPS¹, JON L. OLIVER^{1,2}, PAUL J. READ^{3,4,5}, G. GREGORY HAFF⁶, GREGORY D. MYER^{7,8,9,10}, and RHODRI S. LLOYD^{1,2,11}

¹Youth Physical Development Centre, Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UNITED KINGDOM; ²Sports Performance Research Institute New Zealand (SPRINZ), AUT University, Auckland, NEW ZEALAND; ³Institute of Sport, Exercise and Health, London, UNITED KINGDOM; ⁴School of Sport and Exercise, University of Gloucestershire, Gloucester, UNITED KINGDOM; ⁵Division of Surgery and Interventional Science, University College London, London, UNITED KINGDOM; ⁶School of Medical and Health Sciences, Edith Cowan University, Joondalup, AUSTRALIA; ⁷Emory Sport Performance and Research Center, Flowery Branch, GA; ⁸Emory Sports Medicine Center, Atlanta, GA; ⁹Department of Orthopaedics, Emory University School of Medicine, Atlanta, GA; ¹⁰The Micheli Center for Sports Injury Prevention, Boston, MA; and ¹¹Centre for Sport Science and Human Performance, Waikato Institute of Technology, Hamilton, NEW ZEALAND

ABSTRACT

MOESKOPS, S., J. L. OLIVER, P. J. READ, G. G. HAFF, G. D. MYER, and R. S. LLOYD. Effects of a 10-Month Neuromuscular Training Program on Strength, Power, Speed, and Vault Performance in Young Female Gymnasts. *Med. Sci. Sports Exerc.*, Vol. 54, No. 5, pp. 861–871, 2022. **Purpose:** This study aimed to evaluate a 10-month neuromuscular training (NMT) intervention on isometric and dynamic kinetics, standing long jump (SLJ) distance, speed, and sport-specific performance. **Methods:** Forty-three prepubertal female gymnasts were allocated into either a gymnastics + NMT (gNMT; $n = 16$), gymnastics only (GYM; $n = 15$), or maturity-matched control (CON; $n = 12$) group. The gNMT followed a 10-month, twice-weekly NMT program that targeted movement competency, strength, power, and speed. Vaulting vertical take-off velocity, speed, SLJ distance, and kinetics during an isometric mid-thigh pull (IMTP), countermovement jump (CMJ), and drop jump (DJ) were measured at baseline and thereafter at 4, 7, and 10 months. Within-group differences were calculated using 3×4 repeated-measures ANCOVA. **Results:** Interaction effects were observed for SLJ distance and various IMTP, DJ, and vaulting variables. The gNMT showed significant improvements in IMTP absolute force and SLJ distance after 4 months and each subsequent testing session. IMTP relative force and various CMJ and DJ kinetics significantly improved in the gNMT from 7 months. Significant gains in speed and vaulting take-off velocity occurred after 10 months. The GYM group achieved some significant improvements in CMJ impulse, absolute isometric strength, and DJ spring-like behavior, whereas the CON group did not experience any changes. **Conclusions:** The addition of NMT to gymnastics training improved various isometric and dynamic kinetics, SLJ distance, speed, and vaulting take-off velocity in the gNMT, changes that were not equally evidenced for GYM or CON. The threshold for most of the training-induced adaptations observed in IMTP relative force, CMJ and DJ kinetics, sprint speed, and vaulting were achieved after 7 months, emphasizing the efficacy of long-term NMT programs for young gymnasts. **Key Words:** GYMNASTICS, YOUTH, PREPUBERTAL, RESISTANCE TRAINING, STRENGTH AND CONDITIONING, LONG-TERM ATHLETIC DEVELOPMENT

Several position statements from international sporting organizations have recommended that all young athletes should engage in neuromuscular training (NMT) during

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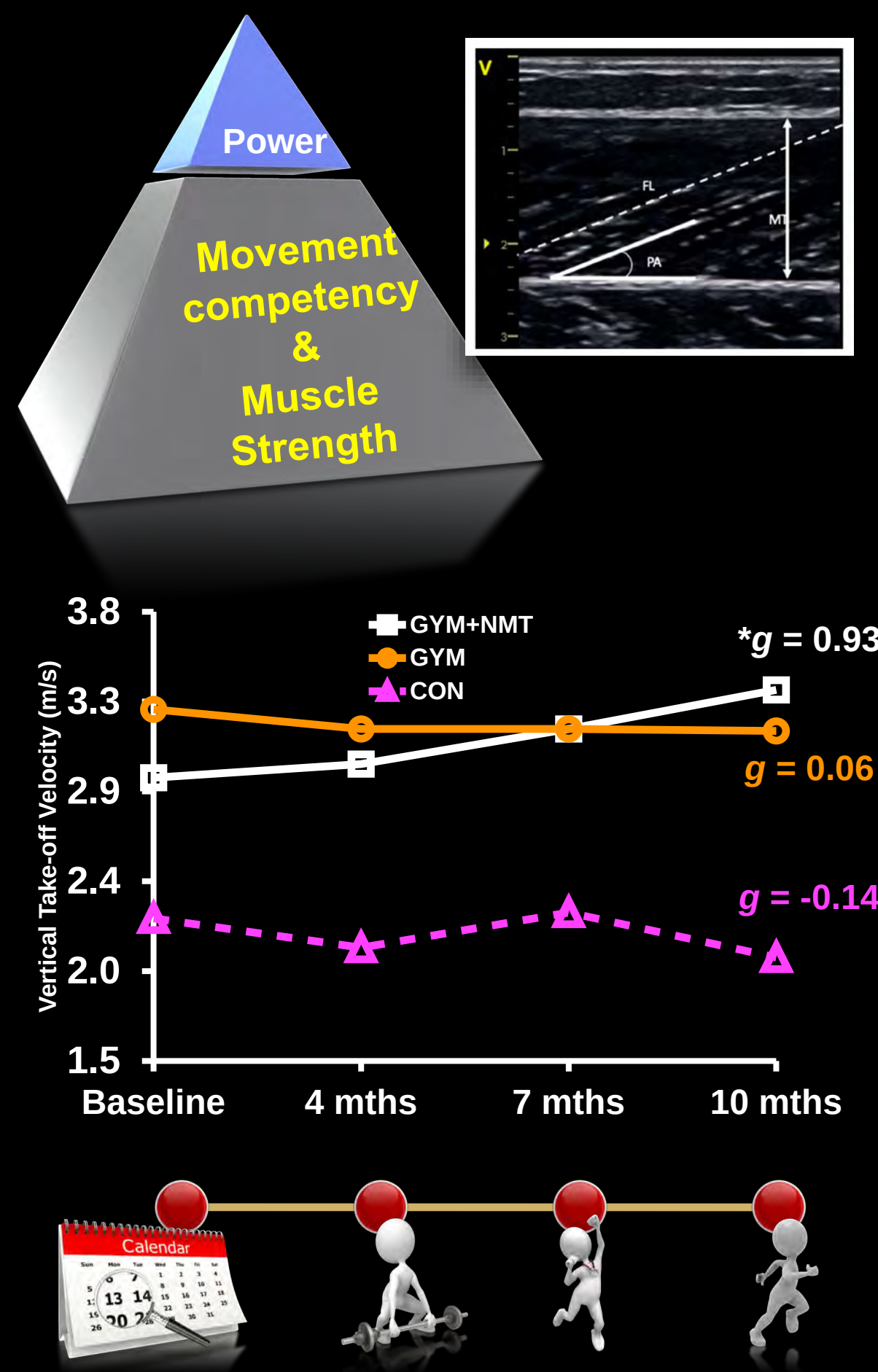
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the prepubertal years (1,2). Supplementing technical sports training with NMT reduces sport-related injury risk, improves movement skill proficiency, and enhances physical qualities associated with athletic performance (3,4). Principally, NMT combines a range of training modes, including resistance training, plyometrics, speed, dynamic balance/stabilization, and postural control to elicit neuromuscular adaptations (3,5). Despite a growing body of evidence showing the efficacy of NMT in general youth populations (3,5,6), whether similar improvements in fitness can be realized in young athletes that participate in high training volume sports such as gymnastics remains unclear. One study in prepubertal female gymnasts revealed that 8 wk of NMT significantly improved levels of movement competency and trunk endurance (7); however, the authors concluded that higher intensities and longer training durations would be required to realize adaptations in neuromuscular variables, such



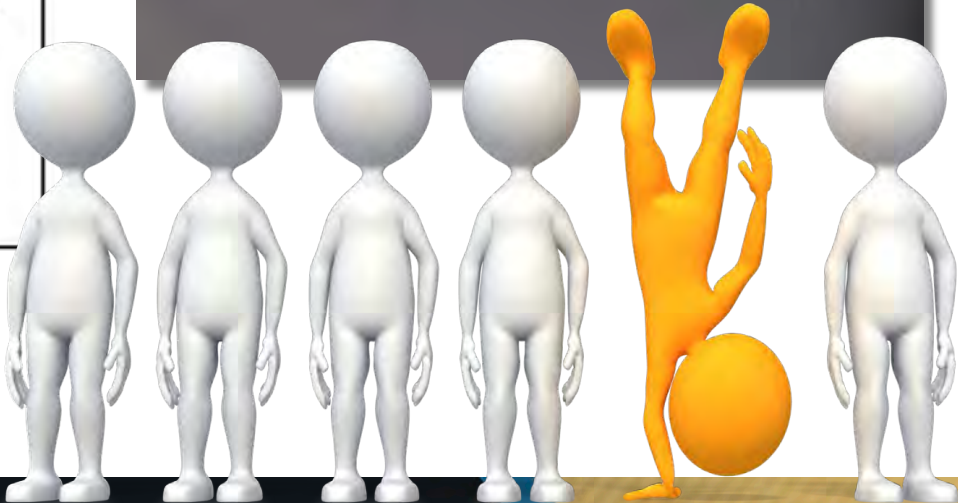
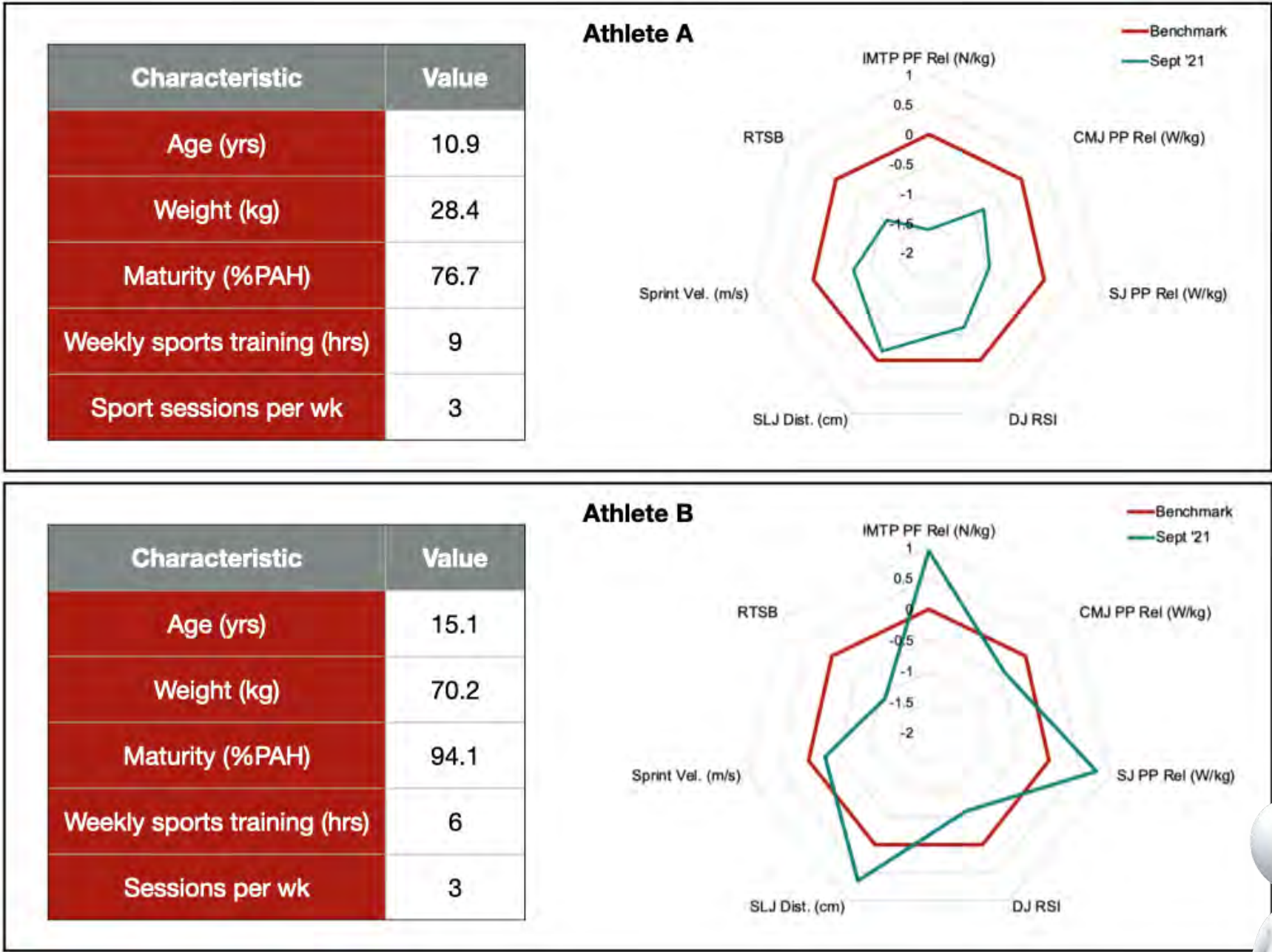


PROGRAMME DESIGN

FACTORS TO CONSIDER



FACTORS TO CONSIDER...





EXAMPLE SESSIONS

Developing Athletic Motor Skill Competencies in Youth

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ABSTRACT

Synergistic development of muscular strength and motor skill competency is central to long-term athletic development. However, these qualities need to be developed in a logical and progressive manner, and training methods need to be developmentally appropriate, engaging, and enjoyable for young athletes to help them build a positive association with strength and conditioning-based activities. This article aims to provide a resource for coaches to use when developing the athletic motor skill competencies in youth, including game-based activities, and a more structured resistance training curriculum.

INTRODUCTION

Leading position statements surrounding long-term athletic development (LTAD) emphasize the need for children and adolescents to engage with strength and conditioning programs that help develop fitness and appropriate levels of athleticism to enable safe and effective participation in sports and physical activity (5,29). Increasing muscular strength and motor skill competency is central to the LTAD mission

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(33), due to their close association with physical performance (55) and injury risk reduction (28). Recent research has demonstrated that young athletes will often show substandard levels of movement competency, which typically reflects an impaired range of motion and limited muscular strength and stability (49,57,58). Furthermore, recent trends in physical fitness show children are less physically capable than 10 years ago (53). Regular and early participation in interventions throughout childhood and adolescence will likely improve movement mechanics, enhance force expression, minimize the risk of sports-related injury, and promote positive long-term health outcomes in youth (17).

Practitioners working with youth populations face the challenge of developing context-specific frameworks that facilitate the development of motor skill competency and basic levels of muscular strength. Traditionally, motor skill competency and muscular strength are viewed as separate entities; however, it is important to acknowledge that these athletic qualities should be developed synergistically (9). Effective motor skill execution is governed by the efficient combination of cognitive processing, correct fundamental movement patterns, and force production and absorption (32). Therefore, the ability to perform any form of movement (e.g., jumping,

bracing, lifting, catching, accelerating, and decelerating) requires some level of force to be produced or absorbed; thus, increasing muscle and connective tissue strength should be viewed as an important adjunct to developing coordination and overall motor skill competency.

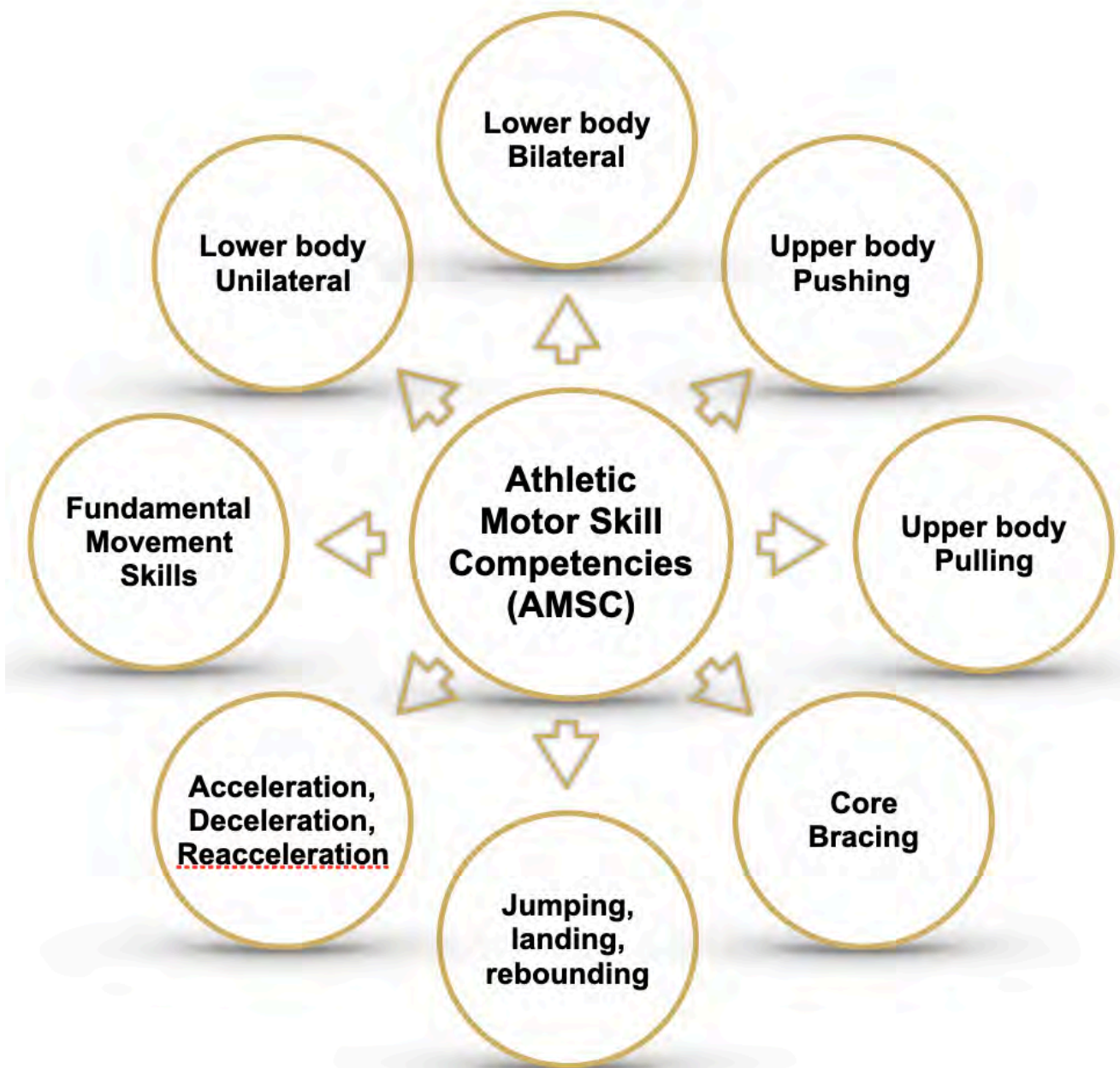
ATHLETIC MOTOR SKILL COMPETENCIES

All practitioners will adopt and refine their own methods of practice and training philosophies when programming and coaching athletes. Although LTAD should be viewed holistically (35), a central mission is to build solid foundations of athleticism that enable young athletes to participate in sports and physical activity with effective, efficient, and safe technique. To this end, athletic motor skill competencies (AMSC; Figure 1) were proposed as the foundational movements that underpin all athletic movements (36).

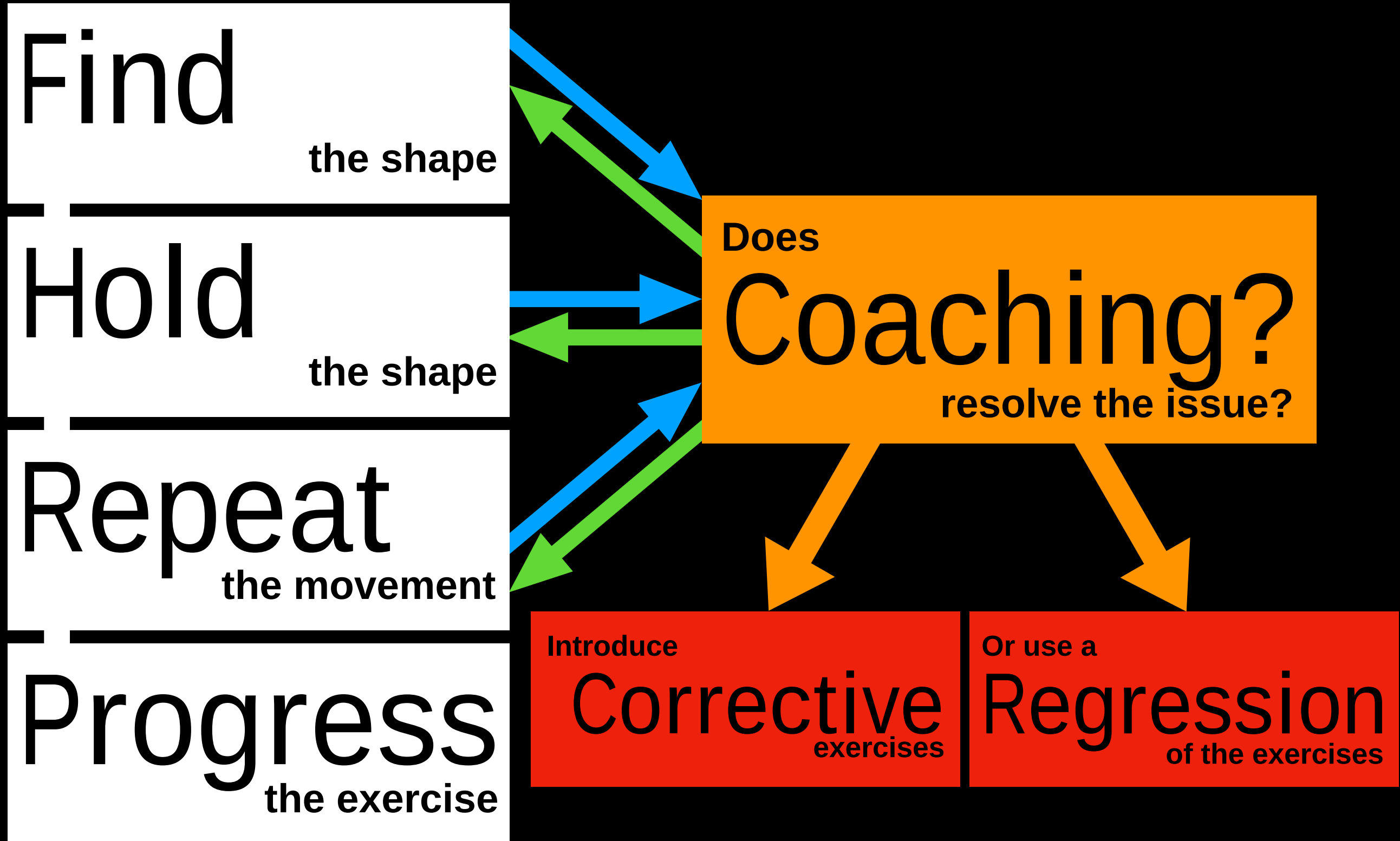
Most athletic tasks will typically use a combination of numerous AMSC to be performed competently. For example, notwithstanding the contribution of perceptual decision making and cognitive input, the act of cutting during an agility movement will rely on efficient unilateral

KEY WORDS:

resistance training; games; obstacle course; children; long-term athletic development



WHAT DOES “COMPETENT” LOOK LIKE?

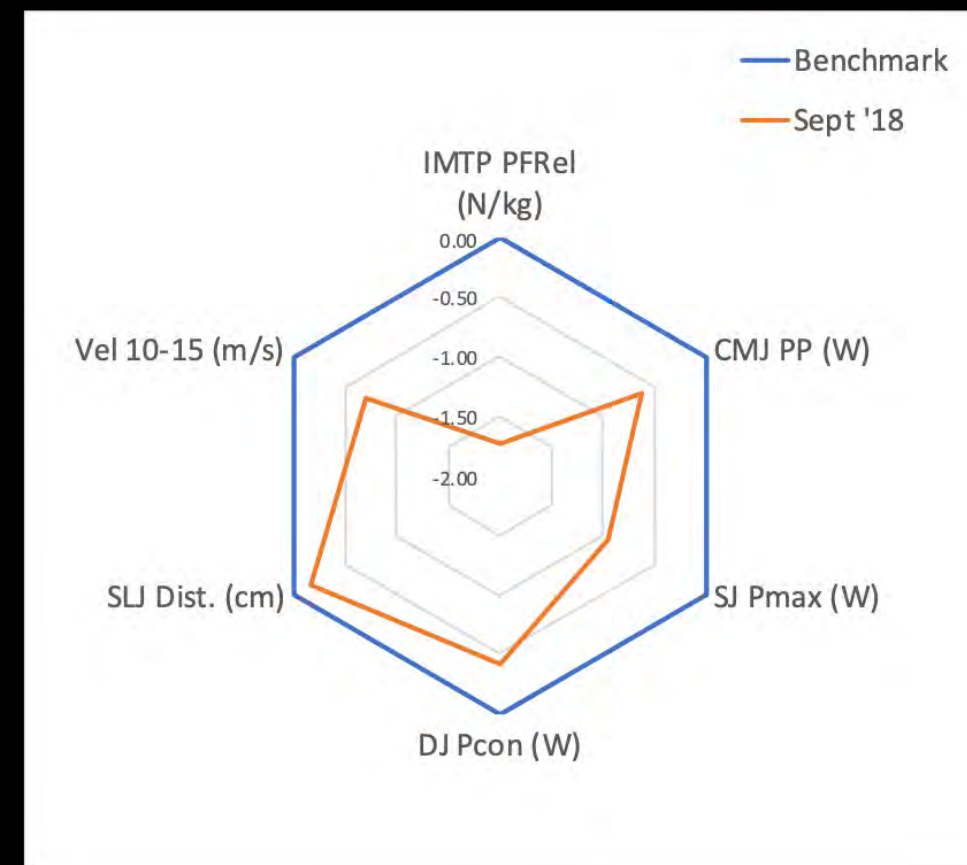


PRINCIPLES OF PROGRESSION

Simple	Task Complexity	Complex
Pre-planned	Exercise Stimulus	Reactive
Single	Skills per Exercise	Multiple
Linear	Movement Direction	Multidirectional
Slow	Repetition Velocity	Fast
Assisted	Resistance	External load
Static	Movement Type	Dynamic
Exploratory	Nature of Programme	Structured

CASE STUDY 1

Characteristic	Value
Age (yrs)	10.9
Weight (kg)	28.4
Standing height (cm)	136.0
Seated height (cm)	69.4
Maturity (%PAH)	76.7
Weekly gymnastics (hrs)	8
Sessions per wk	3
Other sports	None
Injury notes	None
S&C training history	0



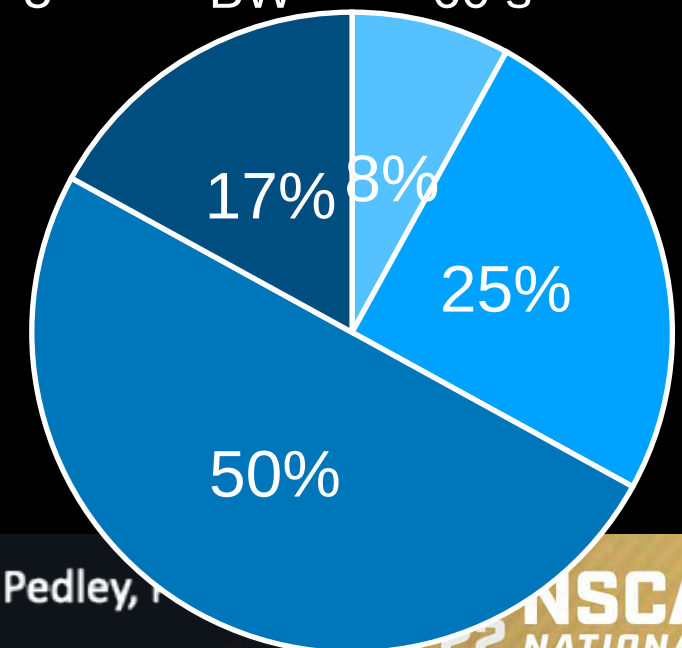
PROGRAMME CONSIDERATIONS



EXAMPLE SESSION

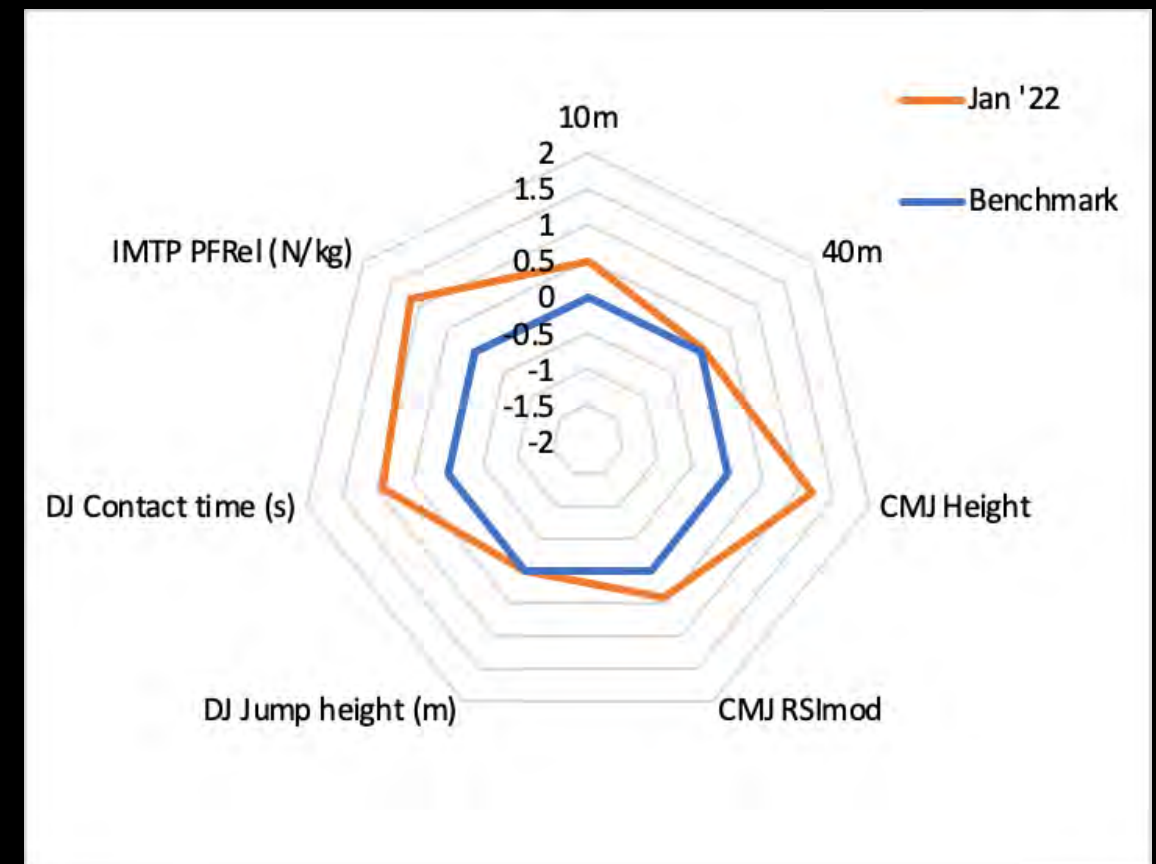
General Preparation			Movement competency & strength			
Time	Exercise	Notes	Sets	Reps	Intensity	Rest
~5 mins	Drop catch game in partners	Engagement activity	3	5	BW	60 s
~15 mins	Animal shape obstacle course	Warm up	3	3-10	BW	60 s
~30 mins	Counter-balance squat	Partners	3	10	BW	60 s
	Hip hinge with dowel		2	10	BW	60 s
	Isometric split squat	Add perturbations	3	10	BW	60 s
	Press up	Choose difficulty	3	8	BW	60 s
	Banded row		3	8	BW	60 s
~10 mins	Side plank + jump & stick	Partners	2	5 ES	BW	60 s
	Acro balances	Challenge time	2	5	BW	60 s

- Engagement activity
- Warm up
- Main
- Challenge



CASE STUDY 2

Characteristic	Value
Age (yrs)	16.0
Weight (kg)	80.3
Standing height (cm)	183.0
Seated height (cm)	92.0
Maturity Offset	2.26
Weekly gymnastics (hrs)	7
Sessions per wk	5
Other sports	None
Injury notes	None
S&C training history	2 yrs

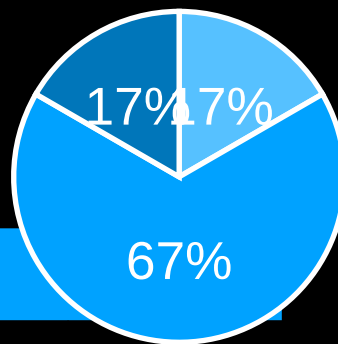


PROGRAMME CONSIDERATIONS



EXAMPLE SESSION

■ Warm up
■ Main
■ Challenge

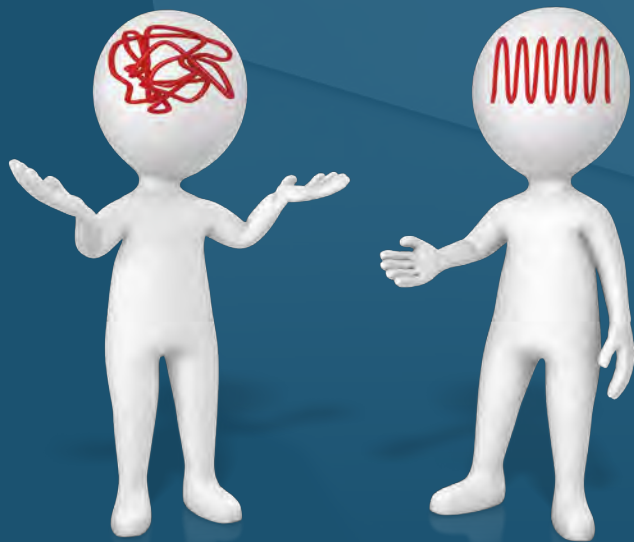


General Preparation		Movement competency & strength				
Time	Exercise	Notes	Sets	Reps	Intensity	Rest
~10 mins	Deadbug	Trunk anti-extensor potentiation	2	8 ES	BW	30 s
	Hammie walks	Posterior chain potentiation	2	4	BW	30 s
	SL Glute bridge	Posterior chain potentiation	2	6 ES	BW	30 s
	Yoga push up	Hip + thoracic mobility	2	8	BW	30 s
	Spiderman	Hip + thoracic mobility	2	6 ES	BW	30 s
	Inchworm	Hip mobility + trunk potentiation	2	8	BW	30 s
	Sit to stand	Hip and ankle mobility	2	8	BW	30 s
	SL Hop + stick	Unilateral balance + potentiation	2	5 ES	BW	30 s
~40 mins	1a Back squat	Bilateral triple extension	3	5	70%	60 s
	1b Max hopping	Max JH, no compromise on CT	3	5	BW	120s
	2a Split squat	Unilateral triple extension	3	5	70%	60 s
	2b Countermovement jump	Focus on speed of execution	3	5	BW	120s
	3a Z press	Thoracic extension potentiation	3	8	80%	60 s
	3b Wall angels	Thoracic mobility	3	10	N/a	120s
	4a Bent over row	Hip hinge and horizontal pull	3	8	80%	60 s
	4b Counterbalanced side lunge	Frontal plane mobility	3	10	10kg	120s
~10 mins	Bear crawl relay	Cone on back constraint				

BEFORE

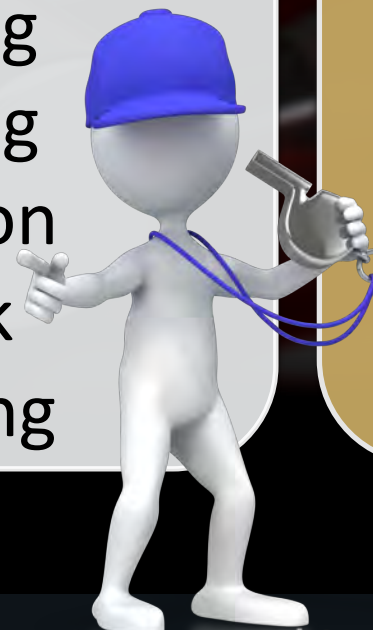
Prepare
Planning
Goals

Individualisation
Sport/activity demands
Interdisciplinary
“Flexible” plan



DURING

Organisation
Ownership*
Greet by door
Coach:athlete relation.
Engagement tasks
Communication
Levelling
Humour & Fun
Demonstration
Cueing
Scaffolding
Positioning
Observation
Feedback
Questioning



AFTER

Monitoring*
Reflection
Evaluation
Feedback loop



Lloyd *et al.* (2019)



QUESTIONS & ANSWERS

THANK YOU TO COLLEAGUES

