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Within-Season Variation of Fitness in Elite Youth Female Soccer Players

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Abstract

Study Background: The within-season variation in fitness measures of elite youth female soccer players (<18 years of age) has not been investigated previously. Further knowledge of this area could allow more effective periodization of training, whilst also enabling coaches to design appropriate long-term athlete development models. This study investigated the within-season variation of fitness test performance in elite youth female soccer players.

Methods: Nineteen elite youth female soccer players aged 11–14 from two age group soccer teams (under 13 (U13) [n=10] and under 15 (U15) [n=9] corresponding to year of birth) participated in this study. A within-players design was used to investigate the variation of selected fitness parameters. The players completed a fitness testing protocol pre-, mid- and post-season, which tested 5 m acceleration, 20 m sprint, repeated-sprint (RSA) and change-of-directional (CoD) performance. Test-retest reliability for these tests was also investigated.

Results: Substantial performance decrements were observed in 5 m acceleration, 20 m sprint and CoD performance at both mid- and post-season when compared to pre-season, with greatest decrements observed in the U13 players. For both groups the most substantial decrements were observed in CoD Performance (6.9 and 10.1% for U13 and U15s, respectively), and 5 m acceleration (8.0 and 3.6% for U13 and U15s, respectively) performance at the mid-season point. RSA was improved post-season in the U13s in comparison to pre- and mid- season. Test-retest reliability for the 20 m sprint, CoD and RSA tests was satisfactory (r>0.68), the 5 m acceleration test demonstrated poor reliability (r=0.24).

Conclusion: In elite youth female soccer players, acceleration, sprint and CoD performance decreased over the course of a season, whilst RSA performance improved in U13 players. Coaches should consider the impact of physiological preparation on performance when working with youth female soccer players, implementing training interventions and recovery strategies accordingly to prevent reduced performance capacity during competition.

Keywords: Within-season variation; Youth soccer; Fitness testing; Women's soccer

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Abbreviations: RSA: Repeated-sprint ability; CoD: Change-of-direction; U13: Under 13; U15: Under 15

Introduction

Participation in women's soccer has increased significantly in recent times. It is estimated that women in 132 countries participate in soccer, with up to 1.4 million alone in the UK playing at various age groups and levels of competition [1,2]. Despite this, female soccer players are seen as a specialist population [1]. The demands of elite women's soccer are reported to be similar to that of elite male soccer regarding the mean match intensity (~85% of maximal heart rate), and distance covered (~10 km) [3]. However, research has reported that junior female players possess a significantly lower aerobic capacity than that of elite senior players, indicating that the activity pattern of youth soccer will differ somewhat from senior play [4]. Irrespective of this, it would still appear that good anaerobic capabilities and well-developed aerobic fitness are pre-requisites to successful performance at elite level in women's soccer, regardless of age [5].

Fitness testing throughout a competitive season is of great importance for the identification of strengths and weaknesses of individuals and sports teams [6]. More specifically, performance level on soccer-specific tests has been found to correlate with match performance in terms of the distance covered at high-intensity-a key determinant of physical match performances-emphasizing the value of such tests to soccer performance [5,7]. The variation in fitness over the course of a season has been investigated extensively in male soccer players of different playing standard, age and nationality [6,8-11]. In general, the existing research on male players has indicated that over the course of a season aerobic performance is improved mid-season, after which a decline is reported; whilst sprint and agility performance improve throughout the competitive season [6,8-11]. However, much of the research has focused on only few components of fitness, which does not present a holistic evaluation of the players in the respective studies. Furthermore, the existing research has not tested at regular intervals throughout a season, only testing pre and post, or pre and mid-season. To successfully evaluate the within-season variation in fitness it is important to test regularly, to identify how different phases of training may affect performance and how key components of fitness vary at different points of a season.

Although the existing literature on women's soccer has focused on either the activity pattern of the game, the relationship between performance on a number of tests, or the variation in performance across age groups [3,5,12], the application of this knowledge to training and physical performance over the course of a season remains unexplored. The within-season variation in fitness parameters of elite youth female soccer players (<18 years of age) has also yet to be investigated. This may be due to younger female players also being seen as a specialist population, or the fact that women's soccer within younger players has only received more attention in recent times [1,12]. Along with the evaluation of the effectiveness of training interventions, periodic fitness testing of youth soccer players may provide important information for coaches regarding the identification of fatigue, in addition to facilitating the construction of appropriate long-term athlete development models [13]. Therefore,

the aim of this study was to assess the within-season variation of physical performance in two age-group teams of elite youth female soccer players. A secondary aim was to investigate the test-retest reliability of the fitness testing battery used within this study.

Materials and Methods

Experimental approach

A within-players design was used to investigate the within-season variation of selected fitness measures in two groups of elite youth female soccer players. A fitness testing protocol was performed by the players at three points across the competitive season.

Participants

A total of nineteen elite youth female soccer players aged 11–14 from two age-group soccer teams (Under 13 (U13) [n=10] and Under 15 (U15) [n=9] corresponding to year of birth) belonging to an 'English FA Girls Centre of Excellence' playing at the highest level of domestic competition available for youth female players, participated in this study. An initial sample of 32 (fourteen U13 players and eighteen U15 players) players were selected, however due to injury and non-attendance at the testing sessions, this was reduced. Any players who had suffered musculoskeletal injuries in recent history (as defined by the 'Centre of Excellence' physiotherapist) or suffered from any other medical condition which may be affected by maximal exercise were excluded. All players participated in the same training programme, participating in two technical/soccer-specific sessions and one specific conditioning session per week. The competitive season extended from August 2011 through to April 2012. The players and their guardians were required to provide informed consent prior to commencement of the testing period. Ethical approval was obtained from the University ethics board and the study was run in accordance with the declaration of Helsinki.

Procedures

Peak-height velocity (PHV) refers to the period of most rapid growth in height during adolescence and may influence performance in various tasks [14]. Prior to the pre-season testing session anthropometrical details (Table 1) were measured for each of the players, allowing for the occurrence of PHV to be predicted using a sex-specific multiple regression equation based on body mass, height, sitting height, limb length and age [14]. The testing protocol was performed pre-season (August), mid-season (December: prior to the winter break) and post-season (May: ten days post-season). These testing points were chosen with the following rationale; pre-season testing followed the main training phase, mid-season testing allows evaluation of the impact of early season training and match loads on the players, and post-season testing allows analysis of how the measures of fitness were affected over the entire season. During the season the players participated in a total of 29 competitive matches (0.8 games per week between pre- and mid-season; and 0.9 games per week between mid- and post-season).

Table 1: Participant characteristics for U13 and U15 soccer teams at the initiation of the testing period.

	U15	U13
Age (y)	13.4 ± 0.5	11.8 ± 0.7
Predicted age at PHV (y)	12.5 ± 0.7	12.3 ± 0.3
Height (cm)	157.5 ± 8.0	148.1 ± 8.7
Weight (kg)	48.8 ± 11.6	38.9 ± 7.6

Testing protocol

The testing protocol consisted of three maximal tests, which were selected based on the findings of previous literature, which demonstrated each component to be strongly related to match performance and/ or is performed to a high level by elite soccer players [7,12,15-17]. Acceleration, speed, repeated sprint ability (RSA) and change-of-directional (CoD) performance were monitored over the course of a season. Prior to the testing sessions the players completed the same standardized warm-up procedure consisting of light jogging, change of directional drills, and short sprints.

5 m acceleration and 20 m sprint performance

All players performed two 20 m sprints in an indoor sports hall, with the fastest time being recorded. Timing gates were placed at 0, 5, 10, 15 and 20 m, respectively to obtain split times, with all sprint times being recorded to the nearest 0.01 s using a light gate timing system (Smart speed, Fusion Sport, Australia). The first 5 m split was used as a measure of acceleration. All sprints were completed from a standing start, 0.5 m behind a starting line. The players were required to commence sprinting as soon as a green light was displayed on the timing gates and were encouraged to run through the finish line.

RSA and CoD performance

A 6×40 m RSA test was used as detailed by Impellizzeri et al. [18]. The players were given a 5 s countdown prior to each sprint. Timing gates were placed at 0, 15, 25 and 40 m of the shuttle sprint to obtain split times. Prior to the RSA test a criterion run was performed, which was followed with a five-minute rest period. The first sprint of the test was required to be within 2.5% of the criterion run to ensure maximal effort was being given. In the instance where this was not the case, players were given further rest, which occurred with only two individuals throughout the three testing sessions. Mean sprint time was recorded for the participants. CoD performance was recorded as the time taken to complete the 10 m section of the 40 m shuttle sprint between 15 and 25 m, where a 180 degree turn occurred. The best time taken from the criterion run and first sprint to complete this 10 m section of the test was used as a measure of CoD ability.

Reliability of the 5 m acceleration, 20 m sprint, CoD and RSA tests was examined during the pre-season phase using a test-retest experimental design, whereby participants completed two trials separated by 7 days. Testing was performed at approximately the same time of day. For the reliability study, 23 players completed both RSA trials. Thirty five players completed both trials for the 5 m acceleration, 20 m sprint and CoD tests. Times recorded during the second trial acted as the pre-season score for each of the players.

Statistical Analysis

Data are presented as the mean ± SD. Using a custom-made spreadsheet [19], all data were log transformed and then back transformed to obtain the percent difference, with uncertainty of the estimates expressed as 90% confidence intervals, between performances on the pre-, mid-, and post-season fitness tests. This is the appropriate method for quantifying changes in athletic performance [20]. Inference was then based on the disposition of the confidence interval for the mean difference to the smallest worthwhile effect; the probability (percent chances) that the true population difference between trials was substantially beneficial, harmful (>0.2 SDs) or

trivial was calculated as per the magnitude-based inference approach [21]. These percent chances were qualified via probabilistic terms assigned using the following scale: <0.5%, most unlikely or almost certainly not; 0.5–5%, very unlikely; 5–25%, unlikely or probably not; 25–75%, possibly; 75–95%, likely or probably; 95–99.5%, very likely; >99.5%, most likely or almost certainly [20]. For the purposes of this manuscript beneficial was replaced with the term 'faster' and harmful replaced with 'slower'. All reliability measures were calculated using a custom-made spreadsheet [22].

Results

For all players, test-retest reliability was satisfactory for the 20 m sprint, CoD and RSA tests (Table 2). The 5 m acceleration test demonstrated low test-retest reliability. The players' performances for the four fitness measures across the duration of the soccer season are displayed in figures 1a-d.

There were substantial performance decrements in acceleration time during both the mid- and post-season tests when compared to the pre-season tests (Figure 1, Table 3), with the magnitude

Table 2: Test-retest reliability data for the four performance variables used in this study.

Test	Trial 1 (± SD)	Trial 2 (± SD)	Mean change (90% confidence interval)	% Typical error (90% confidence interval)	Test-retest r (90% confidence interval)	ICC (90% confidence interval)
5 m acceleration	1.19 ± 0.09	1.16 ± 0.07	-0.03 (-0.06 to 0.00)	5.9 (4.9 to 7.5)	0.24 (-0.04 to 0.48)	0.23 (-0.04 to 0.48)
20 m sprint	3.56 ± 0.21	3.56 ± 0.22	0.00 (-0.04 to 0.04)	2.6 (2.2 to 3.3)	0.82 (0.70 to 0.90)	0.83 (0.71 to 0.90)
CoD	2.66 ± 0.17	2.73 ± 0.17	0.07 (0.04 to 0.11)	3.5 (2.9 to 4.4)	0.68 (0.49 to 0.81)	0.71 (0.53 to 0.82)
RSA	8.44 ± 0.32	8.38 ± 0.31	-0.05 (-0.12 to 0.01)	1.4 (1.2 to 1.9)	0.86 (0.72 to 0.93)	0.86 (0.73 to 0.93)

Table 3: Percentage difference, along with the 90% confidence interval and practical inferences, for the between test comparisons (pre-, mid-, and post-season) on performance measures in U13 (n = 10) and U15 (n = 9) female youth soccer players.

	Difference	90% Confidence interval	Q	Qualitative probabilistic descriptors
5 m Acceleration				
U13				
Mid - Pre	8.0%	4.9% to 11.3%	1.00	"Most likely" slower
Post - Mid	-2.8%	-6.6% to 1.2%	0.80	"Likely" faster
Post - Pre	5.0%	1.9% to 8.2%	0.98	"Very likely" slower
U15				
Mid - Pre	3.6%	-0.2% to 7.6%	0.88	"Likely" slower
Post - Mid	-1.6%	-3.6% to 0.5%	0.71	"Possibly" faster
Post - Pre	2.0%	-2.4% to 6.6%	0.66	"Possibly" slower
20 m Sprint				
U13				
Mid - Pre	3.1%	0.7% to 5.6%	0.94	"Likely" slower
Post - Mid	-2.7%	-4.9% to -0.5%	0.93	"Likely" faster
Post - Pre	0.3%	-1.1% to 1.8%	0.66	"Likely" trivial
U15				
Mid - Pre	1.5%	0.0% to 2.9%	0.86	"Likely" slower
Post - Mid	-1.4%	-3.4% to 0.7%	0.75	"Likely" faster
Post - Pre	0.1%	-2.6% to 2.9%	0.38	"Possibly" slower/ trivial
CoD				
U13				
Mid - Pre	6.9%	3.6% to 10.3%	1.00	"Most likely" slower
Post - Mid	-2.2%	-6.7% to 2.5%	0.73	"Possibly" faster
Post - Pre	4.1%	1.6% to 6.6%	0.98	"Very likely" slower
U15				
Mid - Pre	10.1%	5.2% to 15.2%	1.00	"Most likely" slower
Post - Mid	-5.7%	-9.0% to -2.3%	0.98	"Very likely" faster
Post - Pre	4.2%	0.1% to 8.6%	0.90	"Likely" slower
RSA				
U13				
Mid - Pre	0.2%	-1.1% to 1.6%	0.69	"Likely" trivial
Post - Mid	-1.6%	-2.9% to -0.2%	0.83	"Likely" faster
Post - Pre	-1.3%	-2.3% to -0.3%	0.80	"Likely" faster
U15				
Mid - Pre	1.7%	-0.3% to 3.8%	0.84	"Likely" slower
Post - Mid	-1.0%	-3.2% to 1.1%	0.65	"Possibly" faster
Post - Pre	0.4%	-0.9% to 1.8%	0.48	"Possibly" trivial

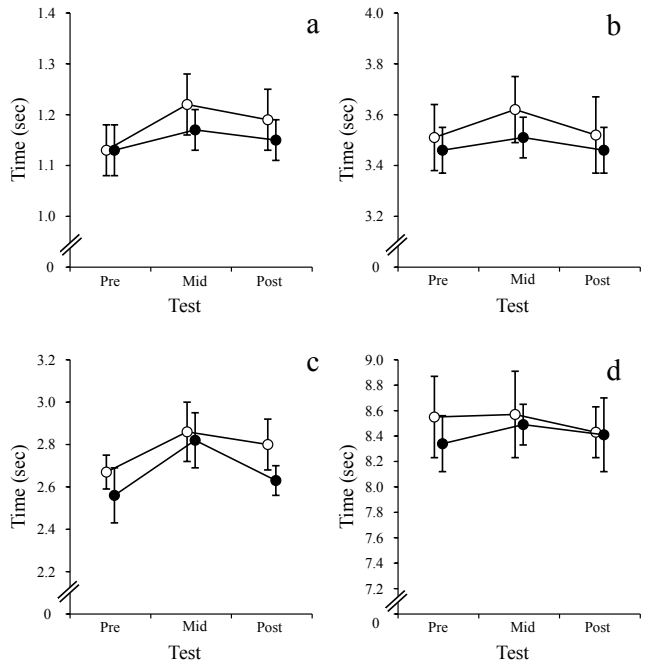

Figure 1: 5 m acceleration (a), 20 m sprint (b), CoD (c) and RSA (d) times for the U13 (open circles) and U15 players (closed circles) on pre-, mid- and post-season fitness tests.

of the decrements being greater for the U13 players. A substantial improvement was observed in acceleration time on the post-season test when compared to the mid-season test; the magnitude of this improvement was again greater for the U13 players. Twenty meter sprint performance was substantially slower during the mid-season test when compared to the pre-season test. Slower 20 m sprint times were also observed during the post-season test, although these performance changes were less clear. When compared to the mid-season test, 20 m sprint performance was substantially improved post-season in both groups, with the magnitude of the improvement being greater for the U13 players.

For both the U13 and U15 players there were clear, substantial performance decrements in CoD performance during both the mid- and post-season tests when compared to the pre-season test. Performance on this test improved substantially during the post-season test when compared to the mid-season test; the magnitude of the improvement was greater for the U15 players. Times on the RSA test were substantially faster for the U13 players during the post-season test when compared to pre- and mid-season tests, with a trivial difference between the pre- and mid-season tests. The U15 players recorded slower times during the mid-season test when compared to the pre-season test. Post-season test performance was faster, although this difference was less clear as was the post-pre-season comparison.

Discussion

The aim of this study was to assess the within-season variation in 5 m acceleration, 20 m sprint, repeated-sprint ability (RSA) and change-of-directional (CoD) performance in elite youth female soccer players. The test-retest reliability of each of the tests was also investigated. Our main findings were that performance decrements were observed in all of the fitness measures at the mid-season test in comparison to pre-season test. With the exception of RSA in the Under 13 (U13) players, performance remained below pre-season levels in both age-groups at the post-season test, with the most substantial decrements being observed in the U13 players. Performance on the 5 m acceleration and CoD tests elicited the most substantial differences over the course of the season. RSA in the U13 players was improved post-season in comparison to both pre- and mid-season. Test-retest reliability for the 20 m sprint, CoD and RSA tests was high, whilst the 5 m acceleration test was shown to have below satisfactory reliability.

Fitness testing enables sports scientists and coaches to analyze the training status of their players and use the information to provide individual profiles of players' respective strengths and weaknesses [23]. Whilst our study provides novel descriptive data for elite youth female soccer players, the main focus of our study was to evaluate within-season changes in selected measures of fitness. The existing literature has reported that power, speed and agility remains unchanged over the course of a season in male soccer players [8,24]; our study provided contrasting findings with performance decrements in acceleration, sprint and CoD performance. It is possible that these decrements may be a consequence of reduced training time or increased focus on the technical aspect of performance as oppose to physiological preparation following the pre-season phase [25]. Without monitoring the players' training loads, however, this cannot be confirmed. The diminished performance level in these measures of fitness could be related to the effect of maturation (as measured via PHV) on the players, as performance can be negatively affected around the peak growth period i.e. PHV - this occurs around the age of 11-13 in females, which can cause a disturbance in motor coordination abilities [13,26-28]. However, a limitation of our study was that maturation was measured only once during the study period.

RSA was improved post-season in the U13 players, with only small decrements observed in the under 15 (U15) players; however it is unclear why RSA improved despite performance decrements in sprint and CoD performance. Improvements in aerobic capacity have been reported to lead to a reduced sprint decrement on a RSA test, which is manifested via improved mean sprint times [29,30]. However, research in this area has provided equivocal findings [24], and a further limitation of our study was that we were unable to report any measures of aerobic fitness for the players.

The performance decrements observed in acceleration and CoD performance in particular are meaningful as these components are important to successful performance. Although high speed activities make up only a small proportion of the total activity performed during a game (~11%), this is said to be performed during the most vital moments of a game [31]. The fact that performance on the RSA test was improved in the U13s is important, as existing research demonstrates a strong relationship between RSA and the amount of high-intensity running and sprints performed during a game [7,18]. Although there is a paucity of research investigating the relationship of acceleration, sprint and CoD performance with match running performance, it is highly likely that reduced performance in any of these components will negatively impact match physical performance.

The stochastic nature of team sports dictates that fitness tests are used as indicators of fitness as opposed to predictors of performance [23]. Nonetheless, when monitoring progression of an athlete with performance or other fitness tests, it is important to take into account the magnitude of the smallest worthwhile enhancement in performance and the uncertainty or noise in the test result [32].

With this in mind our test-retest reliability data provides important information for both researchers and practioners alike for the interpretation of meaningful changes in test performance on an individual level. The typical error reported in our study for 20 m sprint performance and RSA mean was slightly higher than that reported in the previous literature (1.3% and 0.8%, respectively) [18,33], but nonetheless provides further support for the reliability of these tests. Previous research does not appear to have used a similar protocol for measures of acceleration or CoD therefore the data presented is novel, and therefore we offer a viable test for CoD performance, whilst providing important information for the measurement of acceleration in young female soccer players.

In summary, fitness testing across a season is a valuable tool for coaches to assess the fitness levels of soccer players and allow appropriate interventions and/or recovery strategies to be put in place. Our findings demonstrate that during a season, maximal performance levels in certain measures of fitness can be reduced in young female soccer players. This may be due to the effect of the training stimulus imposed on the players, or possibly changes in maturation status. Coaches must consider how the training load imposed on young players throughout a season may affect performance in competition, and it is important that training programs devised for youth female soccer players provide adequate attention to maintaining acceleration speed and CoD in particular. Although RSA was improved in the U13s and only affected minimally in the U15s, it is possible that this could have been further developed had pre-season performance levels in sprint, acceleration and CoD performance been maintained or improved throughout the season. However, further research is required to support such a supposition.

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