‘The’ pathway towards the elite level in Dutch basketball

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Chapter 3

Development of repeated sprint ability in talented youth basketball players

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Abstract

Factors affecting repeated sprint ability (RSA) were evaluated in a mixed-longitudinal sample of 48 elite basketball players 14-19 years of age (16.1 ± 1.7 years). Players were observed on 6 occasions during the 2008-2009 and 2009-2010 seasons. Three following basketball-specific field tests were administered on each occasion: the shuttle sprint test for RSA, the vertical jump for lower body explosive strength (power), and the interval shuttle run test for interval endurance capacity. Height and weight were measured; body composition was estimated (percent fat, lean body mass). Multilevel modeling of RSA development curve was used with 32 players (16.0 ± 1.7 years) who had 2 or more observations. The 16 players (16.1 ± 1.8 years) measured on only 1 occasion were used as a control group to evaluate the appropriateness of the model. Age, lower body explosive strength, and interval endurance capacity significantly contributed to RSA ($p \leq 0.05$). Repeated sprint ability improved with age from 14 to 17 years ($p \leq 0.05$) and reached a plateau at 17-19 years. Predicted RSA did not significantly differ from measured RSA in the control group ($p \geq 0.05$). The results suggest a potentially important role for the training of lower body explosive strength and interval endurance capacity in the development of RSA among youth basketball players. Age-specific reference values for RSA of youth players may assist basketball coaches in setting appropriate goals for individual players.

Keywords: intermittent, high intensity, athletes, adolescence, interval

Introduction

Basketball is characterized by intermittent activity ranging from short bursts of high intensity to longer periods of moderate intensity and recovery[1,2]. The game includes frequent moderate to high intensity sprints (every 21 seconds on average) and changes in types of movements (walking, jogging, running, sprinting) every 2 or 3 seconds on average[1,3]. It is generally accepted that the repeated sprint ability (RSA) test captures the essence of game demands for basketball and other sports[4-6]. Given the perceived importance of RSA in basketball and other sports, data addressing the development of RSA in youth basketball players are relatively limited[7,8].

Elite basketball players differ from non-elite in speed and change-of-direction speed[9], which are key elements of RSA. However, information on the development of RSA in youth basketball players is relatively limited. Such information is potentially useful for coaches and trainers for player development and evaluation, individualizing training, and talent selection. Data on the development of RSA of talented youth basketball players can also serve as a reference for evaluation of players of different ages and talent levels with the goal of individualizing training and improving performance.

Anaerobic and aerobic energy systems influence RSA, i.e., predominantly anaerobic adenosine triphosphate (ATP) provision during sprinting and aerobic processes during recovery[6]. Anaerobic power can be measured by lower body explosive strength (vertical jump), which is highly relevant to basketball[3] and highly correlated with peak power in the Wingate test ($r = 0.86$)[10]. Aerobic power can be measured with a test of interval endurance capacity that indicates how well high intensity activities can be maintained. It also includes the ability to recover during low intensity activities[11]. The interval shuttle run test (ISRT) is a measure of the interval endurance capacity and is moderately to highly correlated with VO2max ($r = 0.77$). Given the interval nature of basketball, the ISRT is a useful measure of aerobic interval endurance capacity for the sport.

Changes in body size and composition with growth and maturation influence the anaerobic and aerobic performances[12-14] and may in turn influence RSA. Height and lean body mass (LBM), which are highly correlated, can potentially influence RSA. It has been suggested that height may negatively influence change-of-direction speed[15] and in turn negatively affect RSA[16], whereas LBM is mainly composed of muscle mass which influences anaerobic power[17] and positively affects RSA.

Repeated sprint ability improves, on average, with age in cross-sectional samples of youth. The changes are often attributed to age-related improvements in lower body explosive strength and interval endurance capacity[18,19]. Muscle mass, the vertical jump, and aerobic capacity have well-defined adolescent growth spurts; muscle mass and vertical jump have their growth spurts, on average, shortly after peak height velocity, although aerobic capacity (peak VO2) has its spurt close in time with peak height velocity[14].

This study evaluates the development of RSA and potentially related factors in a mixed-longitudinal sample of talented adolescent basketball players 14-19 years of age. It was hypothesized that chronological age, height, LBM, lower body explosive strength, and interval endurance capacity are primary determinants of the development of RSA in adolescent players. It was also hypothesized that the development of RSA in basketball players varies with age from mid-adolescence to late adolescence.

Methods

Experimental approach to the problem

Observations were made on youth players over 2 consecutive seasons. Measurements were taken before (September), during (January/March), and after (June) the 2008-2009 and 2009-2010 competitive seasons. Given the nature of sport (injury, drop out, changing interests, etc.), all players were not seen at each occasion. Number of measurement occasions for each player by age group is shown in table 3.1. The majority of players (n=32, 16.0 ± 1.7 years) had multiple measurements (3.6 ± 1.4), whereas the remainder (n=16, 16.1 ± 1.8 years) had a single observation. The sample of players with multiple observations was suitable for modeling RSA development curve. Players observed on only one occasion served as a control group to test the appropriateness of the model.

Table 3.1: Number of measurements per player by age group.

	Number of measurements						
Age category	1	2	3	4	5	6	Total
14	2	2	3	4	2	3	16
15	6	2	6	10	4	3	31
16	2	5	0	7	7	0	21
17	1	3	0	7	5	5	24
18	3	1	3	3	4	5	19
19	2	9	0	1	5	2	19
Total measurements	16	22	12	32	30	18	130
Number of players	16	11	4	5	6	3	48

Subjects

The sample included 48 select male basketball players from the Dutch Basketball Academy in the north of the Netherlands. There are a total of 5 youth basketball academies in the Netherlands. All players were considered talented based on performances relative to peers and potential for the professional level20. Players ranged from 14 to 19 years (16.1 ± 1.7 years) and were members of the selection team for 2.4 ± 1.1 years. As a group, the sample had 6.4 ± 2.1 years of experience in the sport. During the season, players completed 6.6 ± 2.3 practices and had 1.1 ± 0.3 games per week. All subjects (and/or parents when under 18) provided written informed consent. The study was approved by the ethics committee of the Medical Faculty of the University Medical Center Groningen, University of Groningen. Trainers and board of the basketball club also approved the study.

Procedures

Decimal age was recorded as the difference between date of birth and date of each observation. Age groups were defined with the whole year as the mid-point, i.e., 15 years = 14.50-15.49 years. Three following basketball-specific field tests were used: the shuttle sprint test (SST) for RSA, the vertical jump (VJ) for lower body explosive strength (power), and the ISRT for interval endurance. Height and weight were measured and body composition was estimated. All observations were made between 4 and 9 PM. Players were randomly divided into two groups. The first group started with anthropometry and body composition, whereas the second group started with the field tests. Sufficient rest between tests was ensured. Tests were performed at an indoor sports hall; measurements were carried out by the same individuals.

Shuttle Sprint Test. The SST is part of the shuttle sprint and dribble test and measures RSA[21]. Players performed 3 maximal 30 m shuttle sprints, with 20 seconds rest between sprints. Each sprint had three 180-degree angle turns (figure 3.1). Elapsed time was measured with photocell gates (Eraton BV, Weert, The Netherlands) placed at hip height. The outcome measure for RSA was the total time of the 3 * 30 m sprints (s). The test is reliable and valid[21-23].

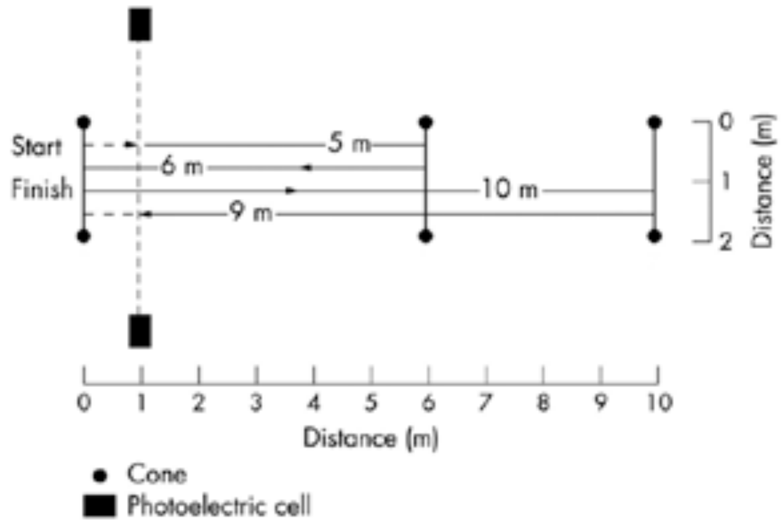

Figure 3.1: Course for the Shuttle Sprint Test (SST), adapted from Lemmink et al. (2004)[21].

Vertical Jump. The VJ was measured using a yardstick vertical jump device[24]. The device measures the height to which players could push away small sticks placed horizontally on a pole during a jump. Reaching height was subtracted from the height reached while jumping. The player had 6 attempts, 2 jumps with the dominant leg, 2 with the non-dominant leg, and 2 with both legs with sufficient rest between jumps. The highest attempt was retained for analysis. This VJ protocol has established reliability[24].

Interval Shuttle Run Test. The ISRT requires players to run back and forth on a 20 m course[11]. The pace and frequency of runs are regulated by a prerecorded CD with sound signals. Participants are required to be within the safe zone (3 m before the 20-m start line) before the next signal. The signals are recorded in such a way that running speed increases every 90 seconds; players run until exhaustion with a work-rest ratio of 2:1. The ISRT score was the total number of shuttles completed. The ISRT is a reliable and valid maximal field test for athletes in intermittent sports[11,23].

Anthropometry and body composition. Shoes and socks were removed. Height (cm) was measured with a tape fastened to the wall. Weight and percentage fat were assessed with a Tanita Body Fat Monitor, which has established reliability and validity[8]. LBM was estimated as (weight - [weight / 100 * percentage fat]).

Statistical analyses

Mean ± SD were calculated for all variables by age group. Pearson correlations among variables were calculated for the first observation and interpreted using the following guidelines: trivial, $r < 0.10$; small, $r = 0.10$-0.30; moderate, $r = 0.30$-0.50; large, $r = 0.50$-0.70; very large, $r = 0.70$-0.90; and nearly perfect, $r > 0.90$[25]. Because RSA is measured in time with less time implying a better performance, correlations related to RSA have been inverted to assure that for all correlations a positive sign means a better performance.

Multilevel modeling (MLwiN)[26] was used with the mixed-longitudinal subsample (n=32). Given the overlap in ages of the players, it was possible to estimate a 6-year development curve for RSA. Multilevel modeling permits use of measurements with variable spacing between observations[27]. The protocol provides insights of 2 sources of variance; within subject (level 1) and between subject (level 2). In the present analysis, hierarchy was defined as repeated measures (level 1) nested within the individual players (level 2). The first step in the multilevel modeling of RSA was to create a satisfactory variance structure using decimal age. Vertical jump, ISRT, height, and LBM were subsequently added. All variables were checked for interaction effects with age, and random slopes were considered. Multivariate analysis of variance was used to evaluate differences in RSA between age groups. Significance was set at 0.05.

The appropriateness of RSA regression model was investigated in the cross-sectional subsample of players with only 1 measurement (control group, n=16) using absolute reliability[28]. Repeated sprint ability was compared with predicted RSA based on the multilevel model. The difference between RSA and predicted RSA was calculated and tested against a mean difference of 0. Significance was set at 0.05.

Results

Descriptive statistics for all variables in the total mixed-longitudinal sample are summarized by age in table 3.2. Correlations among the basketball-specific field tests, body size, and estimated body composition at initial observation are shown in table 3.3. Repeated sprint ability was positive and at best moderately correlated with lower body explosive strength ($r = 0.35$). The correlation between RSA and interval endurance capacity was small and also positive ($r = 0.24$). These results thus show that a faster repeated sprint is associated with better performance on both the VJ and ISRT. The correlation between lower body explosive strength and interval endurance capacity was also moderate but positive ($r = 0.45$). Height was not related to RSA ($r = 0.01$) and LBM was not related to interval endurance capacity ($r = 0.01$). However, the correlation between LBM and RSA was small and positive ($r = 0.23$) and that between LBM and lower body explosive strength was moderate and positive ($r = 0.44$). As expected, height and LBM had a very large positive correlation ($r = 0.86$). The correlation between height and explosive strength was positive and moderate ($r = 0.39$), whereas that between height and interval endurance capacity was small and negative ($r = -0.11$).

Table 3.2: Mean (SD) for basketball-specific functional tests, body size and estimated body composition for the total mixed-longitudinal sample of youth basketball players by age group (n=48; number of measurements=130).

Cohort (yr)	n	Age (y)	SST* (s)	VJ (cm)	ISRT (20m runs)	Height (cm)	Weight (kg)	Percentage fat (%)	LBM (kg)
14	16	14.09	26.09	70.50	96.94	176.37	62.03	8.61	56.63
		(0.27)	(0.94)	(0.01)	(17.48)	(0.13)	(14.27)	(2.34)	(12.56)
15	31	14.96	25.69	75.81	99.90	183.65	70.22	10.19	63.14
		(0.29)	(1.04)	(0.09)	(19.57)	(0.07)	(11.30)	(3.05)	(8.62)
16	21	15.96	25.97	81.00	104.22	188.75	75.79	11.77	66.75
		(0.27)	(1.21)	(0.10)	(19.48)	(0.07)	(11.92)	(4.45)	(7.32)
17	24	16.99	25.18	84.67	118.00	190.36	77.62	8.93	70.70
		(0.33)	(0.97)	(0.07)	(15.27)	(0.05)	(7.56)	(3.00)	(7.49)
18	19	18.03	25.14	86.42	115.05	188.92	78.79	6.17	73.87
		(0.27)	(1.02)	(0.07)	(22.23)	(0.11)	(8.64)	(1.67)	(7.52)
19	19	18.95	24.82	87.47	115.26	189.06	82.87	7.90	76.26
		(0.26)	(1.04)	(0.05)	(15.57)	(0.09)	(7.65)	(1.94)	(6.52)

Note: *Lower score indicates a better performance; SST = Shuttle Sprint Test; VJ = Vertical Jump; ISRT = Interval Shuttle Run Test; LBM = Lean Body Mass.

Table 3.3: Correlations between repeated sprint ability (RSA), Lower body explosive strength, Interval endurance capacity, Height, and Lean Body Mass (LBM) in total sample of basketball players at the first observation (n=48)

	RSA	Lower body explosive strength	Interval endurance capacity	Height	LBM
RSA	1.00	[illegible]	[illegible]	[illegible]	[illegible]
Lower body explosive strength		1.00	[illegible]	[illegible]	[illegible]
Interval endurance capacity			1.00	[illegible]	[illegible]
Height				1.00	[illegible]
LBM					1.00

Note: [illegible]

The model for RSA is summarized in table 3.4. Age ($x^2[1] = 19.78$, $p \leq 0.05$) significantly improved the model. Age^2 was added second but did not improve the model (x^2 [1] = 1.71, $p \geq 0.05$). Subsequently, lower body explosive strength (x^2 [1] = 10.87, $p \leq 0.05$) and interval endurance capacity (x^2 [1] = 4.89, $p \leq 0.05$) were added and both significantly improved the model. The addition of height and LBM did not significantly improve the model ($p \geq 0.05$). All variables were also tested for interaction with age, but no interactions improved the model ($p \geq 0.05$). Random slopes also did not improve the model fit ($p \geq 0.05$).

Table 3.4: Multilevel model for the Shuttle Sprint Test (SST) in talented youth basketball players.

Fixed Effects	Coefficient	Standard Error	p
Constant	[illegible]	[illegible]	< 0.05
Age	[illegible]	[illegible]	< 0.05
Vertical Jump Test	[illegible]	[illegible]	< 0.05
Interval Shuttle Run Test	[illegible]	[illegible]	< 0.05
Random Effects	**Variance**	**Standard Error**	
Residual variance at level 1	[illegible]	[illegible]	
Between player variance level 2	[illegible]	[illegible]	
Deviance	[illegible]		
Deviance of empty model	[illegible]		
p < 0.05			

The model suggests that better RSA performances (i.e., lower score in seconds on the SST) are achieved by older players with better lower body explosive strength and interval endurance capacity. The residual intercept (level 1) indicates that within-player variance is 64% (0.525/[0.299 + 0.525] * 100). Between-player variance (level 2) is 36% (0.299/[0.299 + 0.525]). Coefficients for age, lower body explosive strength, and interval endurance capacity are unstandardized. Their effects can be interpreted as follows: adding 1 year of age results in the same improvement as increasing in VJ by 4.2 cm (0.161 / 3.816 * 100) or increasing in ISRT by 13.4 trajectories (20 m runs) (0.161 / 0.012).

Figure 3.2 shows predicted RSA scores. Performance improves (times decrease) in a linear and significant manner between 14 and 17 years ($p < 0.05$) and then seem to plateau as differences between 17 and 19 are not significant ($p > 0.05$). Overall, RSA performance improves (times decrease), on average, by 1.58 seconds from 14 to 19 years, but estimated mean improvement in RSA is -0.41 s per year between 14 and 17 years compared to only -0.17 s per year between 17 and 19 years.

The test for absolute reliability indicates no significant difference between actual RSA and predicted RSA based on the above model applied to the control group ($t = 1.06$; $df = 16$; $p > 0.05$). This result highlights the appropriateness of the multilevel model.

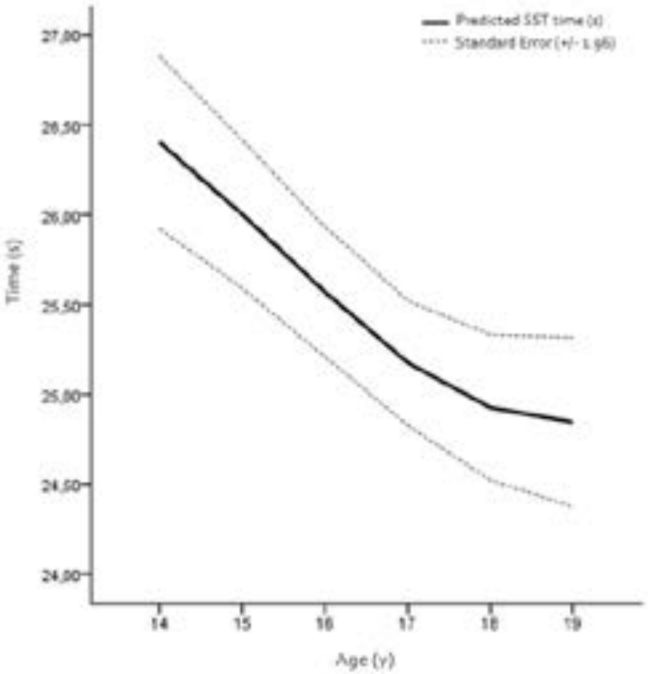

Figure 3.2: Development of the predicted scores on the Shuttle Sprint Test (SST) with the Standard Error of the prediction from 14 to 19 years in talented youth basketball players. Significant differences ($p < 0.05$): age 14 vs. ages 16-19, age 15 vs. ages 16-19, age 16 vs. ages 14-15 and 18-19, age 17 vs. ages 14-15, age 18 vs. ages 14-16, age 19 vs. ages 14-16.

Discussion

The present study considered the development of RSA and related growth and functional parameters in a mixed-longitudinal sample of elite youth basketball players 14-19 years of age. Repeated sprint ability is seen as an important characteristic for youth basketball players to become successful[9]. The positive correlation between RSA and lower body explosive strength indicates that a better lower body explosive strength is related to a better RSA. This is in line with a recent study of Stojanovic et al. (2012)[29], which shows that counter movement jump (also measuring lower body explosive strength) is a predictor of RSA in basketball players. The correlation between RSA and interval endurance capacity was also positive, indicating that a higher interval endurance capacity is related to a better RSA. Because the SST, VJ, and ISRT tests are sufficiently reliable[11,21,24], it is likely that a learning effect was minimal; moreover, basketball training and monitoring protocols do not require these tests on a regular basis.

Age, lower body explosive strength, and interval endurance capacity were significant predictors of RSA, whereas height and estimated body composition were not significant predictors in the multilevel analysis. The utility of lower body explosive strength and interval endurance capacity as significant predictors of RSA implies that both functions should be essential parts of training programs for youth players in an effort to improve RSA, which is recognized as an essential component of basketball performance[1,30].

Repeated sprint ability also improved, on average, with age from 14 to 19, but the major improvement occurred between 14 to 17 years. This may contribute to the larger within-player variance (64%) compared with between-player variance (36%).The difference in variances implies that improvement in RSA within individual players is greater than improvements between players. This in turn is related to individual differences in growth and maturation and also functional development[31]. Potential individual differences in the timing of adolescent growth in size, composition and functional capacities highlight a need for further study of RSA among youth athletes. This study found no relation between height and RSA. Repeated sprint ability was measured with the SST in which players had to perform a trajectory with turns of 180-degree angle (i.e., change-of-direction speed). Therefore, smaller players might benefit from their height in this test. The negative and positive effects of height may neutralize each other, suggesting no distinct relation between height and RSA. Another explanation might be the homogeneity concerning the height of players. Most players have probably stopped growing in height after the age of 15 years.

Performances in lower body explosive strength, interval endurance capacity, and motor skills in general improve during male adolescence[14,32-34]. On average, adolescent gains in static strength and lower body explosive strength (vertical jump) reach peak velocity shortly after peak height velocity (PHV) of the growth spurt, whereas aerobic power has its peak velocity at the same time as peak height velocity. Thus rapid improvements from 14 years may be explained, in part, by normal variation in the adolescent growth spurt[35]. This is suggested in the observations of Mendez-Villanueva et al. (2011)[36] who noted a reduction of age-related differences in RSA when predicted age at PHV was statistically controlled in soccer players 11-18 years of age. Though interesting, the results for soccer players were likely influenced by limitations using predicted age at PHV. The predictions are influenced by chronological age, i.e., the younger the boy, the earlier the age at PHV; and the older the boys, the later the age at PHV[37].

The large improvement in RSA from 14 to 17 years may reflect in part the adolescent spurt in lean tissue and continued growth in muscle mass into later adolescence[14]. This would be reflected in greater muscle cross-sectional area which increases exponentially in males until 17 years[38]. The relative influence of growth and maturation is less with increasing age in later adolescence, i.e., in players 17 to 19 years old. At these ages, many youth basketball players are nearing skeletal maturity or are already mature[39]. As such, RSA, lower body explosive strength, and interval endurance capacity improve less than at younger ages.

Although the model could be improved with even more measurement occasions per player over age, by evaluating the model, it can be concluded that single predictive characteristics are significant contributors. In addition, the basketball specific field tests give information about characteristics that are highly relevant for basketball (lower body explosive strength and interval endurance). Consistent with the primary hypothesis of the study, age and two functional capacities, lower body explosive strength and interval endurance capacity, are significant predictors of RSA in adolescent basketball players 14-19 years. Repeated sprint ability develops most rapidly from 14 to 17 years and tends to reach a plateau from 17 to 19 years. Application of the model to the control group (players tested on only 1 occasion) illustrates its predictive utility.

Practical applications

Repeated sprint ability is viewed as an important characteristic for success among talented youth basketball players. As such, it would serve a coach well to be aware of RSA of the players. Repeated sprint ability can be efficiently measured with the Shuttle Sprint Test so that periodic testing of players (e.g., twice per season) would assist in the coaching process. The developmental curve for RSA in this sample of elite youth basketball players can serve as an appropriate reference for the comparison of youth basketball players of the same age. The developmental curve, however, is based on the performances of Dutch basketball players. It is recommended that coaches and trainers develop reference curves for their own players to provide guidance for individual players. Perhaps more important, relationships between RSA and game performances should be addressed. These may serve as a valuable coaching tool with young players. Reference values from the present study are based on select players. As such, they may also be useful for talent identification and selection. Nevertheless, no selection protocol is perfect. Application requires caution and sensitivity to the needs of the young athletes.

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