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A Comparison of Drop Jump and Sprint Parameters in Youth Soccer Players

Genç Futbolcularda Derinlik Sıçraması ve Sprint Parametrelerinin Karşılaştırması

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ABSTRACT

Objective: The purposes of this study were to investigate the comparison of some stretch-shortening cycle (SSC) parameters, and to correlate reactive strength index (RSI) scores from drop jumps (DJ) and sprint times (ST) among maturation groups according to peak height velocity (PHV).

Methods: A total of 108 youth soccer players were included in this study (age: 13.0±1.5 years old; height: 162.7±12.1 cm; weight: 53.1±11.7 kg). Participants were divided into three groups (Pre-PHV, Mid-PHV and Post-PHV) according to calculation using the maturity offset equation. DJ tests from 20 and 40 cm drop heights (DH) and 30 m sprint tests were made by participants. RSI scores were taken during DJs. All tests were performed twice. One-way ANOVA and Welch ANOVA tests were performed to test differences between more than two independent groups for normally-distributed data. If a significant difference was found, Bonferroni and Games-Howell tests were performed for multiple comparisons, respectively. Pearson correlation coefficients were calculated for bivariate correlations between numeric variables, where appropriate. A value of p<0.05 was accepted as significant.

Results: RSI scores of 20 cm DJ were significantly different among groups (p<0.001). RSI of 40 cm DJ of the Pre-PHV group was significantly different than the other groups (p<0.001). All maturation groups were significantly different in terms of sprint times (p<0.001). The RSI of 20 cm DH was correlated with 20 m ST in the Mid-PHV group. But RSI of 40 cm DH was correlated predominantly with 20 m ST in youth soccer (p<0.05).

Conclusion: The main finding of this study was that 40 cm drop height and 20 m sprint distance are more optimal to be used to monitor SSC performances of youth soccer players during maturation.

Keywords: Maturation, drop jump, sprint times, reactive strength index, soccer, peak height velocity

ÖZ

Amaç: Bu çalışmanın amacı zirve boy hızına (ZBH) göre bazı gerilme kısalma döngüsü (GKD) parametrelerinin karşılaştırılması ve derinlik sıçramasından (DS) elde edilen reaktif kuvvet indeksi (RKİ) ile sprint zamanları arasındaki ilişki düzeyinin araştırılmasıdır.

Gereç ve Yöntemler: Çalışmaya 108 (yaş: 13.0±1.5 yıl; boy uzunluğu: 162.7±12.1 cm; vücut ağırlığı: 53.1±11.7 kg) alt yapı futbolcusu katıldı. Katılımcılar olgunlaşmanın

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başlangıcı eşitliği hesaplanarak üç gruba (ZBH-öncesi, ZBH-sırası ve ZBH-sonrası) bölündü. Katılımcılar 20-40 cm düşüş yüksekliğinden (DY) derinlik sıçramaları ile 30 m sprint testi gerçekleştirdiler. RKİ değerleri DS sırasında elde edildi. Testler iki kez yapıldı. Gruplar arasındaki farklar tek yönlü ANOVA ve Welch ANOVA testleri ile belirlendi. Gruplar arası anlamlı bir farkın çıkması durumunda ise Bonferroni ve Games-Howel testleri ile çoklu karşılaştırma yapıldı. İki değişkenli korelasyonlar için Pearson korelasyon katsayısı hesaplandı. Anlamlılık düzeyi $p<0.05$ olarak kabul edildi.

Bulgular: 40 cm'den elde edilen RKİ değerleri açısından ZBH-öncesi grubu diğer gruplardan anlamlı olarak farklıydı ($p<0.001$). Olgunlaşma gruplarının hepsi sprint zamanları açısından anlamlı olarak farklıydı ($p<0.001$). ZBH-sırası grubunda 20 cm DY'den elde edilen RKİ ile 20 m sprint zamanı arasında anlamlı korelasyon elde edildi. Ancak, genel olarak bütün gruplarda 40 cm DY'den elde edilen RKİ ile 20 m sprint zamanının anlamlı olarak ilişkili olduğu bulundu ($p<0.05$).

Sonuç: Bu çalışmanın ana bulgusu, 40 cm DS ile 20 m sprint mesafesinin alt yapı futbolcularında olgunlaşma sürecinde GKD'nin performansı ve takibi için kullanımının daha uygun olduğudur.

Anahtar Sözcükler: Olgunlaşma, derinlik sıçraması, sprint zamanı, reaktif kuvvet indeksi, futbol, zirve boy hızı

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INTRODUCTION

During human locomotion, such as running, jumping, hopping etc., muscle contraction is typified by a combination of eccentric lengthening followed immediately by concentric shortening contraction, termed as stretch shortening cycle (SSC) (1). This counter-movement produces muscle force, a mechanism affected by stretch reflex, tendon elongation, reactivation, and residual force enhancement (2). The ability of athletes to effectively use the stretch shortening cycle is important in many sports such as soccer (3,4).

Reactive Strength Index (RSI) is generally described as an individual's muscles' ability to change quickly from eccentric to concentric contraction, which is considered as a measure of 'explosiveness' (5,6). RSI is one of a score of variables in evaluating jump performance in soccer players. RSI is a measure to quantify SSC function, and has been shown to increase with age in the youth (7,8). Studies reveal that RSI is effected by maturation (9,10).

Physical performance is related to biological maturation during childhood and adolescence (11,12). It is stated by pediatricians and clinicians that considering biological maturation in developing training programs to optimize training adaptation, and minimize the occurrence of health problems is important (13). Therefore, observing the development of physical performance in terms of SSC outputs is critical, while these outputs depend on maturation status (14). The purposes of this study are to compare the differences of some SSC parameters (jump and sprint) and to correlate RSI scores obtained from drop jumps with sprint times, among maturation groups (pre-, mid- and post-PHV).

MATERIAL AND METHODS

Participants

A total of 108 male football players (Age 14.0 ± 1.5 yrs; height 162.7 ± 12.1 cm; weight 53.1 ± 11.7 kg) were included in this study. Their training programs included only technical and tactical exercises except plyometrics, or other physical conditioning contents, from the beginning of their soccer life. Before the study, each participant's coaches and parents were informed about measurement procedures. Written consent to participate in the study was obtained from them in accordance with the Declaration of Helsinki. Ethical approval was provided by the Non-interventional Clinical Researches Ethics Board of Hacettepe University.

Procedure

All tests were carried out in the indoor sports facilities of Hacettepe University Faculty of Sport Sciences. All tests were run on the same day. The measurement sequence was randomly designed. Before testing, physical characteristics such as weight, height and sitting height were assesed by using a digital platform scale (Tanita TBF 401-A, Japan) and a stadiometer (Holtain Ltd, UK). Then, a warm-up protocol was performed similar to that in training or match, usual for all participants. It took no more than 15 min and consisted of jogging and dynamic warm-up exercises. After the warm-up, drop jump (DJ) tests from 20 and 40 cm drop heights (DH) were made before a 30 m sprint test. Each jump test was carried out twice and 1 min rest was given between each trial. Also a 10 min rest was given between DJ tests and the 30 m sprint test. Apart 30 m sprint times, 10 m and 20 m split times were also recorded. The sprint test was also performed twice and a 5 min rest period was given between each trial.

Performance Tests

Drop jump (DJ) test: DJ tests were performed from 20 cm and 40 cm drop heights. During each test, participants were instructed to hold their hands on their waist, and to step off by one leg without jumping from the box and landing with both legs. They were also instructed to jump vertically as fast as possible after landing, and to land to the same take-off point. Each jump test was performed twice, and the highest jump height and the highest RSI scores were recorded by the Fusion Sport Smart Jump system (Australia).

Sprint test: The 30 m sprint run test was used to evaluate sprinting ability in this study. Timing gates of Fusion Sport Smart Speed were placed at the 10 m, 20 m and 30 m marks to score intermediate times during the sprint run. Participants were instructed to start from a standing start position, without any runs or movements to accelerate before the start line. After two trials, which were performed before and after a 5 min resting period, the fastest 30 m sprint times were recorded.

*Estimation of age at peak height velocity (PHV)***:** PHV is a useful tool to determine the maturation status of children during childhood and adolescence. Estimating the timing of maturation through PHV can be done during these periods.

Age predicted at PHV was calculated by using the below-given equation (EQ1) (15). This equation yields chronological status around PHV. In this study, participants were between -4 and +1 year around PHV. While -4 years means that the participant has still four years until PHV, and +1 year means that a year elapsed since PHV. Participants were divided into three groups as the prePHV (-4, -1 yrs), midPHV (-1, 1 yrs), and postPHV groups (1, 2 yrs).

EQ1: Maturity offset =-9.236 + (0.0002708 x(leg length x sitting height)) + (-0.001663 x (Age x leg length)) + (0.007216 x (Age x sitting height)) + (0.02292 x (mass by stature ratio x 100)).

Statistical Analyses

Statistical analysis was performed using the IBM SPSS Statistics program v23.0. The goodness of fit test of numeric variables to normal distribution was determined using Shapiro-Wilk (for $n \leq 50$) and Kolmogorov-Smirnov (for $n>50$) tests. Descriptive statistics were presented as mean ± SD, median, 1st quartile, 3rd quartile, minimum and maximum. One way ANOVA (when homogeneity of variances assumption was satisfied) and Welch ANOVA (when homogeneity of variances assumption was not satisfied) tests were performed to test the difference between more than two independent groups for normally-distributed data. If significant difference is present, Bonferroni and Games-Howell tests were performed for multiple comparisons, respectively. Pearson correlation coefficient was calculated for bivariate correlations between numeric variables where appropriate. A p-value below 0.05 was accepted as significant.

RESULTS

Descriptive statistics can be observed in Table 1. These were the overall values without consideration of maturation status. Accordingly, the age range was betweeen 11 to 16 years and mean BMI was 19.8±2.3 kg/m^2.

Table 1. Descriptive statistics of participants

Parameters	Mean±SD	Median	1st qua.-3rd qua.	Minimum	Maximum
Age (yrs)	14.0±1.5	14.0	13.0-15.0	11.0	16.0
Height (cm)	162.7±12.1	163.7	153.7-172.1	137.6	186.2
Weight (kg)	53.1±11.7	53.5	43.5-61.4	28.1	77.8
Sitting height (cm)	85.3±6.9	85.2	79.9-91.2	69.7	99.4
Leg length (cm)	77.4±6.0	77.7	72.9-81.1	64.7	92.6
BMI (kg/m^2)	19.8±2.3	19.9	18.2-21.1	14.8	27.4

BMI: body mass index; n=108

Drop jump heights

The post-PHV group displayed the highest jump heights from both 20 cm (29.5 ± 5.0 cm) and 40 cm (30.8 ± 5.1 cm) drop heights than other groups. The lowest scoring group was the pre-PHV group in both drop jumps (22.1 ± 2.9 cm and 22.8 ± 3.8 cm respectively). Drop jump heights reveal a linear increase through maturation groups. In both 20 cm and 40 cm drop jumps, jump heights were differed significantly among groups (p<0.001) (Table 2).

RSI scores

The linear increase of RSI scores (mm/ms) through maturation groups were similar with respect to DJ heights. The highest RSI scores were in the post-PHV group in both 20 cm (1.15 ± 0.34 mm/ms) and 40 cm (1.30 ± 0.38 mm/ms) DJ. Statistically significant differences in terms of RSI scores in 20 cm DJ were found between all maturation groups (p<0.001). According to multiple comparison, the pre-PHV group was significantly different than the other groups in terms of RSI scores in 40 cm DJ (p<0.001), while there was no significantly difference between mid- and post-PHV groups (p>0.05). When RSI scores from both drop heights (20 cm and 40 cm) were compared, the scores in 40 cm DJ were significantly higher than those in 20 cm DJ's in mid- and post-PHV groups (p= 0.019 and p=0.008, respectively). In the pre-PHV group, RSI scores in 40 cm were higher than that in 20 cm DJ (p>0.05) (Table 2).

Table 2. Comparison of drop jump parameters and sprint times among PHV groups

PHV groups	Pre-PHV (n=37) (-4; -1 years)	Mid-PHV (n=36) (-1; 1 years)	Post-PHV (n=34) (1; 2 years)	p
DJ 20 cm	22.1 ± 2.9	25.7 ± 4.9	29.5 ± 5.0	<0.001[a,b,c,d]
RSI20	0.78 ± 0.22	1.04 ± 0.30	1.15 ± 0.34	<0.001[a,b,c,d]
DJ 40 cm	22.8 ± 3.8	26.9 ± 5.8	30.8 ± 5.1	<0.001[e,b,c,d]
RSI40	0.85 ± 0.27	1.17 ± 0.41	1.30 ± 0.38	<0.001[e,b,c]
0-10 m (s)	1.98 ± 0.11	1.87 ± 0.10	1.71 ± 0.11	<0.001[a,b,c,d]
0-20 m (s)	3.47 ± 0.17	3.26 ± 0.18	3.01 ± 0.14	<0.001[a,b,c,d]
0-30 m (s)	4.98 ± 0.25	4.64 ± 0.28	4.28 ± 0.18	<0.001[e,b,c,d]

DJ: drop Jump; RSI: reactive strength index; [a]One way Anova test; [b]Significant difference between "pre-PHV" and "mid-PHV"; [c]Significant difference between "pre-PHV" and "post-PHV"; [d]Significant difference between "mid-PHV" and "post-PHV"; [e]Welch ANOVA test

Sprint times

In all sprint distances (10, 20 and 30 m), while the fastest group was the post-PHV group, the slowest group was the pre-PHV group. This situation shows the linear decrease in sprint times with maturation. This difference among groups was similar for drop jump heights and RSI scores. All maturation groups were statistically significantly different from each other for all sprint distances (Table 2) (p<0.001).

Relationship of RSI scores among sprint times

RSI scores from 40 cm DJ were negatively and significantly correlated with all three sprint times (p<0.05) and correlation levels were moderate in the pre-PHV group (Table 3). In the mid-PHV group RSI scores from both 20 cm and 40 cm DJ were negatively and significantly correlated with 20 m sprint times. In post-PHV group only the RSI in 40 cm DJ was negatively and significantly correlated with 20m sprint times. According to these findings, it may be said that correlation levels between RSI in 40 cm DJ and 20 m sprint times is decreasing with maturation. RSI in both 20 and 40 cm DJ are correlated predominantly with 20 m sprint times in youth soccer.

Table 3. Correlations of RSI scores with sprint times

PHV	RS	Correlation	0-10m	0-20m	0-30m
Pre-PHV	**RSI20**	r	-0.29[a]	-0.34[a]	-0.38[a]
		p	0.187	0.108	0.077
	RSI40	r	-0.44[a]	-0.55[a]	-0.54[a]
		p	**0.035***	**0.006***	**0.007***
Mid-PHV	**RSI20**	r	-0.16[a]	-0.39[a]	-0.35[a]
		p	0.442	**0.047***	0.078
	RSI40	r	-0.20[a]	-0.43[a]	-0.40[a]
		p	0.326	**0.027***	**0.043***
Post-PHV	**RSI20**	r	-0.21[a]	-0.14[a]	-0.20[a]
		p	0.274	0.473	0.320
	RSI40	r	-0.27[a]	-0.38[a]	-0.36[a]
		p	0.172	**0.045***	0.059

*RSI 20: RSI from 20 cm DJ; RSI 40: RSI from 40 cm DJ; PHV= Peak height velocity; RSI: reactive strength index; r: Pearson correlation coefficient; *p<0.05*

DISCUSSION

The main purpose of this study was to compare the differences in drop jump and sprint parameters, considering maturation status. The other purpose was to investigate the correlations between RSI scores, sprint times and drop jump parameters for each PHV group. The main finding of the study was that differences among PHV groups were statistically significant in terms of drop jump and sprint parameters. Byrne et al. (16) state that the optimal RSI score could be found by using box heights between 30 cm and 60 cm in adults. RSI is usually found by using a 5-hopping test (8). Müller et al. (17) measured RSI by using drop jump in 9-14 yr old childrens, optimal drop height of being unclear.

In this study, two different drop heights are used (20 cm and 40 cm). DJ heights (cm) from both drop heights were significantly different and increasing linearly among PHV groups (p<0.001). Significant increases were found in RSI from 20 cm drop height among PHV groups, and RSI scores increased linearly ($p<0.001$). Altough linearly increasing, the pre-PHV group was significantly low in RSI scores from 40 cm drop height ($p<0.001$), and there were no significant differences between mid- and post-PHV groups.

According to Lloyd et al. (18), the main reason of these differences among PHV groups lie in the maturation processes of muscle elastic properties during childhood and adolescence. The contractile and elastic components of SSC gradually increase during maturity (1). Series elastic elements (SEE) of muscle are important for SSC performance. It is stated that SEE changes through maturation during childhood and adolescence. Leg and tendon stiffness is strongly relate to movements such as hopping, maximum speed and running economy which require SSC. These parameters are also important to determine the SSC level during vertical jump (18). Sahrom et al. (1) state that mechanical stiffness which is one of the main indicators of SEE level, differs between 84-334 % among maturation groups. Findings in this study also support this statement, as maturation groups differ significantly ($p<0.001$). The probable reason of this significant difference is stated by Lloyd et al. (19). A reason for this finding might be the decline in motor coordination, depending on differential timings of growth spurt of leg and trunk before PHV. Another possible reason was stated by Moran et al. (20), who tried to explain by the development of hormonal profiles and the musculoskeletal system during maturation.

RSI is an important monitoring instrument of effective SSC usage (3,21), and in this study it significant differences were found among PHV groups ($p<0.001$). This finding supports those of Lloyd et al. (19), who found a significant increase in RSI as well as in jump height of CMJ and SJ through chronological age and PHV. In another study (10), the post-PHV group was significantly outperformed by the pre-PHV group in RSI. Accordingly, it can be said that increasing of RSI depends on development of strength and decreasing in ground contact times, which occur during the maturation process, as for sprinting (22).

Maximal sprint speed develops in a nonlinear fashion during childhood (5-9 yrs) and adolescence (12-14 yrs) (11,23). The major differences in the development of maximal speed during childhood and adolescence occurs between the ages of 12 and 14 in both genders, but mainly in boys due to development of strength (22). Peak improvements in sprint speed occur between 8-18 months before and during the period of PHV. It is also stated that decrements in sprint speed can be seen 12 months before PHV (11,23). More significant improvements were reported in 30 m sprint performances during mid- to two years post-PHV (24).

The performance of maximal sprint speed depends on two factors which are stride length (SL) and stride frequency (SF). It is observed that SL is increasing but SF is decreasing during maturation especially in pre-PHV (25). The changes in kinetic, kinematic and stiffness variables during maturation are associated with sprint performance (23). From the kinetic perspective, the possible reason of the increase in SL is explained with the increase in leg length. But increasing of leg length with growth and maturation influences maximal speed development due to resultant increase of SL. The increase in SL depends on alteration of muscle-tendon characteristics during maturation. This may include increased muscle cross-sectional area (CSA), fascicle length, pennation angle, muscle-tendon junction size and stiffness (25). SL also increases as a result of strength and power augmentation (26). These factors influence motor skill development such as maximal sprint speed around PHV (25). SF may actually decline while ground contact time increases during pre-PHV (22,25). But these variables stabilise around PHV. It is also stated that SF is associated with body mass during maturation, especially in pre-PHV. The increase in body mass may result in that the children spend more time during ground contact (23,25).

In our study all sprint times were decreasing linearly through PHV groups. The differences of sprint times among PHV groups were significant. This finding supports statements in literature, as described above. The differences of sprint times also support other findings of RSI as an indicator of SSC, sprint times being also moderately correlated in each maturation group (Table 3). When sprint times are taken into consideration, it is observed that signicifant relationships were mostly between 20 m sprint times and RSI scores especially in the 40 cm DJ height in age groups. This can be clarified by the effect of the majority of sprint displacements shorter than 20 m (2-4s) in a soccer match (27). Healy et al. (28) state that 20 m is the sprint distance beyond which speed is in maximal transition. It can be said that RSI is also an important parameter to determine the sprint transition phase in these groups (Table 3).

To conclude, according to our findings it can be said that 40 cm drop height and 20 m sprint distance are more optimal to monitor SSC performance of youth soccer players during maturation. During training with youth, it is important to applicate a training program that includes sprint and plyometric workouts. These different abilities of stretch-shortening cycle movements continue to develop linearly within the natural development proccess during maturation.

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