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The Relationship between Passive Lower Limb Flexibility and Kinematic Determinants of Split Leap Performance in Rhythmic Gymnastics

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Abstract

Rhythmic gymnastics requires use of a considerable degree of flexibility and strength. These two abilities allow gymnasts to perform better jumps and leaps. According to recent rules all jumps/leaps must have a defined and fixed shape and height of the jumps /leaps should be sufficient to show corresponding shape. Split leap (SpL) is one of the most preferred elements in rhythmic gymnastics. Purpose of current study was to identify the relationships among kinematic components of SpL and passive flexibility applied during forward split (FSF) and backward split (BSF). 11 rhythmic gymnasts participated in current study. Split balance without help of the hands were performed to evaluate FSF and to evaluate BSF gymnasts hold their penché position. Gymnasts performed SpL with their preferred leg. All tests recorded with a camera (120 frames per second). Spearman Correlation Analysis were performed to explain the relationships between variables. FSF was found to be significantly correlated to BSF (r=0.629; p=0.038), BSF and flight angle showed significant correlation (r=0.692; p=0.018). As a result, it can be reported that to have a better SpL performance trainers should include flexibility and plyometric exercises in the trainings.
Keywords: Rhythmic gymnastics, Flight duration, Split leap performance.

Ritmik Cimnastikte Pasif Alt Ekstremite Esnekliği ve Split Sıçramanın Kinematik Belirleyicileri Arasındaki İlişki

Öz

Ritmik cimnastik önemli derecede esneklik ve kuvvet gerektirir. Bu iki beceri cimnastikçilerin sıçrama ve atlamaları daha iyi yapmalarını sağlar. Son kurallara göre, sıçramalar/atlamalar iyi tanımlanmış şekle ve ilgili şekli gösterecek yüksekliğe sahip olmalıdır. Split sıçrama (SpL), ritmik cimnastikte sıklıkla kullanılan elementlerden biridir. Çalışmanın amacı, Split sıçramanın kinematik komponentleri ile öne (FSF) ve arkaya (BSF) uygulanan pasif esneklik arasındaki ilişkiyi belirlemektir. Çalışmaya 11 ritmik cimnastikçi katılmıştır. FSF için el yardımı olmadan öne split denge uygulanmış ve BSF penché pozisyonunun gerçekleştirilmesi ile belirlenmiştir. Cimnastikçiler tercih ettikleri bacakları ile SpL elementini uygulamışlardır. Tüm testler saniyede 120 kare çeken kamera ile kaydedilmiştir. Değişkenler arasındaki ilişkileri açıklamak için Spearman korelasyon analizi kullanılmıştır. FSF ve BSF istatistiksel olarak anlamlı ilişki göstermiştir (r=0.629; p=0.038), BSF ve uçuş açısı arasında anlamlı ilişki bulunmuştur (r=0.692; p=0.018). Sonuç olarak, daha başarılı SpL tekniği/performansı için antrenörlerin antrenmanlarda esneklik ve pliometrik antrenmanlara yer vermesi önerilir.
Anahtar Kelimeler: Ritmik cimnastik, Uçuş süresi, Split sıçrama performansı.

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INTRODUCTION

There are eight major gymnastics disciplines defined by International Gymnastics Federation (FIG): (1) gymnastics for all, (2) men's artistic gymnastics, (3) women's artistic gymnastics, (4) rhythmic gymnastics (RG), (5) trampoline gymnastics, (6) acrobatic gymnastics, (7) aerobic gymnastics, and (8) parkour. Artistic, rhythmic, and trampoline are recognized for involving highly specialized strength, endurance, speed, agility, balance, power, and flexibility (Silva et al., 2019). Among these disciplines RG is as an artistic and aesthetic Olympic sport with a particular training process (Bobo-Arce and Mendez-Rial, 2013) including complex and difficult handlings with rope, hoop, ball, clubs, and ribbon while performing dance steps (from modern dance, ballet, etc.) to music (Thomas and Thomas, 2019). Furthermore, in RG, performance is influenced by several technical, tactical, physical and psychological factors (Batista, Garganta and Avila-Carvalho, 2019). Generally, RG requires use of a considerable degree of flexibility and strength. RG trainings require many specific assumptions and have high demand from the volume and intensity (Batista et al., 2019). Moreover, for high level performance gymnasts should have a good connection between flexibility and strength (Santos, Lebre and Avila Carvalho, 2016). Gymnasts with preferable flexibility and strength might perform better jumps and leaps by having more height and length during jumps/leaps (Douda, Toubekis, Ayloniti and Tokmakidis, 2008).

Sport events may be classified into three categories as follows: (1) high leap demanding, (2) medium leap demanding or (3) low leap demanding sports. Among these categories high leap demanding sports are in need of that leaping and jumping ability take part in the sport. RG can be defined as a high leap/jump demanding sport depending on the elements performed during choreographies (Abd-el Hamid, 2010). Gymnastics is not a static sport; rules change rapidly and systematically (Sands et al., 2016). As all other sport events, RG has performance evaluation rules, updated and changed every four years, set by FIG RG Technical Committee (Agopyan and Ors, 2019).

The elements of the jumps/leaps group are numerous. The changes of the body attitude in flight, the addition of criteria modify the jump to which is assigned a value based on the level of difficulty. Beyond what the gymnast can perform during the jump, after the take-off phase, it is essential to perform with the best technical perfection the pre-jump that strongly affects the subsequent phases of the jump itself (D'Anna, Tafuri, Forte and Paloma, 2019). Split leap (SpL) is one of the most preferred elements in the leap skills that are explained in the RG rules. SpL has a value of 0.30 (jumps/leaps have values starting from 0.10) and this value can be increased by adding some additional criteria (back bend of the trunk, bending the back leg) to the element. It is also one of the essential basic jumps for younger gymnasts to gather correct technique for more difficult jumps. According to CoP (2017-2020) all jumps/leaps must have a fixed and well-defined shape during the flight phase. Moreover, all gymnasts should have a sufficient height during jumps/leaps to be able to show corresponding shape of the difficulty so that judges can evaluate and count the elements (FIG, CoP 2017-2020). To perform SpL with a correct technique and to get the scores given by judges, it is expected that front split flexibility (FSF) and back split flexibility (BSF) should be at a certain level (Ors, Bayraktar, Şimşek and Ertan, 2018). Moreover, last stride length (LSL), flight time (FT), flight angle (FA),

horizontal distance covered during the jump (HD), height of the flight (HF), the angle between front leg and shoulder (FLSA), and the angle between back leg and shoulder (BLSA) are considered to play an important role for performing the SpL with the correct technique.

When the literature is examined, in contrast with increased popularity of RG, there are very few studies analysed body difficulties for RG (Dyhre-Poulsen 1987; Sousa and Lebre 1996; Sousa and Lebre 1998; Cichella 2009). Because of this limitation, the aim of the current study was to identify the relationships among kinematic components of SpL (LSL, FT, FA, HD, HF, FLSA, and BLSA) and the static flexibility applied during FSF and BSF.

METHODS

Participants

Eleven rhythmic gymnasts (age: 10.6±1.6 years; body height: 1.37±0.12 m body weight: 28.45±6.30 kg; body mass index: 14.89±1.21 kg/m^2; training experience: 4.82±1.60 years; training days per week: 5.5±0.5 days; training time per day: 3.36±0.50 hours; were included in the current study voluntarily. Before tests started study was explained in detail to gymnasts. Written consent was obtained prior to the start of the study. For gymnasts under 18, families signed a written consent before data collection. The local Ethical Committee approved the study (No: 2019/191). The study was conducted in accordance with the principles of Helsinki Declaration.

Data Collection

Flexibility tests carried out in this study consisted of the evaluation of two specific RG movements, executed with preferred lower limb. The limb which effectively performs the task was considered as the preferred lower limb as suggested by Santos et al., (2015). To evaluate FSF, split balance without help of the hands were performed and to evaluate BSF gymnasts hold their penché position (Santos et al., 2015). Moreover, gymnasts performed SpL with their preferred leg. SpL, FSF and BSF specific to RG were recorded with a camera (120 frames per second). During all tests, the camera was placed perpendicular to the centre point. Before the tests started, reflective markers were placed on the gymnasts' specified anatomical places: (1) heel, (2) lateral malleolus, (3) fifth metatarsal, (4) anterior superior iliac, (5) femoral epicondyle, (6) hip, (7) elbow, (8) shoulder, and (9) wrist. All gymnasts performed FSF, BSF and SpL by their preferred leg. FSF and BSF tests were performed once while SpL tests were performed twice. For SpL the average results were considered for analysis. Two-dimensional analysis was performed using Tracker software.

Statistical Analysis of Data

Trial version of the SPSS 22.0 (SPSS Inc., Chicago, IL) package program was conducted for statistical analyses of the study. Descriptive data were calculated as mean±standard deviation. Spearman Correlation Analysis were performed to explain the relationships between variables, after testing the normality of all data and significant level was set at $p<0.05$.

FINDINGS

Table 1. Descriptive statistics of somatic variables and training characteristics

Variables (n=11)	$\bar{X}$ **(Mean)**	**SD**
Age (year)	10.64	1.57
Body Height (cm)	1.37	0.12
Body Weight (kg)	28.45	6.30
Body Mass Index (kg/m^2)	14.89	1.21
Training Experience (year)	4.82	1.60
Training Time per Week (day)	5.55	0.52
Training Time per Day (hour)	3.36	0.50

SD: Standard Deviation

The average age for gymnasts was found to be 10.64 years. Gymnasts average training experience was 4.82 years and they trained approximately 5 days a week (Table 1). Descriptive data are presented in Table 1.

Table 2. Correlation results of the variables

		BSF	LSL	BLSA	FA	HD	HF	FLSA	FT
FSF	r	**0.629***	-0.045	**-0.682***	**0.791****	0.278	-0.164	-0.045	-0.097
	p	0.038	0.894	0.021	0.004	0.408	0.629	0.894	0.778
BSF	r		0.100	**-0.610***	**0.692***	0.564	0.002	-0.196	0.092
	p		0.769	0.046	0.018	0.071	0.995	0.564	0.788
LSL	r			0.345	0.273	0.483	0.443	-0.218	-0.028
	p			0.298	0.417	0.132	0.172	0.519	0.936
BLSA	r				**-0.945****	**-0.615***	-0.151	-0.245	-0.285
	p				<0.001	0.044	0.658	0.467	0.395
FA	r					0.542	0.046	0.145	0.120
	p					0.085	0.894	0.670	0.726
HD	r						0.595	-0.287	0.502
	p						0.054	0.392	0.115
HF	r							0.018	**0.764****
	p							0.957	0.006
FLSA	r								0.354
	p								0.285

*: p<0.05
**: p<0.01

Forward split flexibility was found to be significantly correlated to BSF (r=0.629; p=0.038), BLSA (r=-0.682; p=0.021), and FA (r=0.791; p=0.004). There was a statistically significant relationship between BSF and FA (r=0.692; p=0.018). Moreover, BSF was found to have a negative relationship with BSLA (r=-0.610; p=0.046). BSLA and FA showed statistically negative and strong correlation (r=-0.945; p<0.001). FH and FT were found to have a significant moderate relationship (r=0.764; p=0.006) (Table 2).

DISCUSSION

The purpose of this study was to determine the relationship between kinematic components of SpL element, performed in RG choreographies, and static flexibility applied to front and back. Successful performance on RG depends on the score gymnasts get during the competitions while performing their routines. The evaluation of the routines is based on precision, originality, artistry, and must contain technical difficulties. In the light of such information, it can be said that several physiological factors and technical skills may influence the performance of gymnasts (Di Cagno et al., 2008). Bobo-Arce and Mendez-Rial (2013) in their study, in which they review determinants of competitive performance in RG, reported that not many studies explain a proposal of the determinants of a competitive performance in RG and

%41 of success in RG is explained by explosive strength, floor reaction time, anthropometric characteristics and flexibility (Miletic et al., 2004). RG is a high leap demanding sport as leaping ability is one of the essential components of routines (Di Cagno et al., 2008). According to recent RG rules all jumps/leaps must have a defined and fixed shape during the flight and height (elevation) of the jumps or leaps should be sufficient to show corresponding shape (FIG, CoP 2017-2020). As mentioned in the literature, high values of stature and lower limbs length seemed to be required to reach high performance in RG jumping ability (Di Cagno et al., 2008). To perform SpL in accordance with the necessary criteria defined in the rules book gymnasts should have a certain level of flexibility. Moreover, the technique they perform for the SpL may also have an impact on the performance. According to results of the current study; FSF and BSF were found to have a significant relationship with FA. This result explains that, if gymnasts have a certain and enough level of front and back split flexibilities, they may perform better FA during SpL which will lead them to get the related score for the jump.

On the other hand, during flight phase of jumps/leaps technical figures are performed by the gymnasts and despite the growing popularity of RG there is a lack of biomechanical analysis in the literature (Cichella, 2009). Cichella (2009) analysed kinematics of four different jumps specific to RG and reported that LSL was identified as the less stable variable and FT as the most stable. In our study, LSL did not show significant relationships with any of the other variables while FT was significantly correlated to HF. These results seem to support the findings in the literature. On the other hand, SpL flexibility was found to be negatively related to the HD (Ors et al., 2018). In contrast with this finding, in the current study, FA and HD showed no significant correlation. This difference from the literature can be due to the age of the gymnasts. In our study, gymnasts had an average of 10 years of age while the gymnasts from Ors et al. (2018) had an average of 14 years. According to these ages; gymnasts seem to have different training experiences and they compete in different competition categories this may result to the difference that was found in the current study and literature.

Flexibility is concerned as a fundamental motor capacity for RG (Moraru, 2016). Batista et al. (2019) examined the flexibility and strength in Brazilian and Portuguese gymnasts. They reported that younger gymnasts showed higher results in flexibility assessment in spine joints and scapulohumeral joint and in the hip joints, all gymnasts showed excellent results with preferred lower limb, due to the high requirement of this motor capacity in RG. In our study, gymnasts performed all forward/backward flexibility and SpL tests only with preferred leg. FSF and BSF were found to have significant positive relationships with FA and significant negative relationships with BSLA. In accordance with these findings, it can be said that to have a successful SpL performance gymnasts should have a certain level of forward and backward flexibility levels. This will help them to have greater FA and by doing so they may also keep their body (legs and shoulders) in a better shape. However, only the flexibility does not guarantee the execution of the elements with the necessary range and intensity (Batista et al., 2019). Gymnasts should also have a certain level of training experience to fulfil the execution of increasingly complex elements with high technical demand of the sport.

Another significant outcome of the study is that HF and FT have a positive relationship which means as gymnasts jump higher, they will have a longer FT. This will help them to have more time to perform better flexibilities applied to forward and backward. Moreover, BLSA was found to have a negative significant correlation with both FA and HD. While performing SpL

if gymnasts have greater angle between their back leg and shoulder this will result by having a lower FA and shorter HD. As a result, SpL performance will be affected negatively.

RECOMMENDATIONS

To have a better shape with enough flexibility during SpL; forward and backward flexibilities should be at a certain level. But, as BLSA have a negative correlation with FA we can say that trainers and gymnasts should also focus on position of the trunk/shoulders during the element. As seen in the current study, to have a longer FT, trainers should concentrate on HF during SpL. As a result, it can be suggested that to include more flexibility and plyometric exercises into trainings may be helpful to have a better SpL performance.

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