SPLIT LEAP WITH AND WITHOUT BALL PERFORMANCE FACTORS IN RHYTHMIC GYMNASTICS

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Abstract

In rhythmic gymnastics execution quality depends directly on the level of technical expertise, as well as physical performance of the gymnast. the objective was to study the variation of execution factors, particularly the strength, speed and flexibility when performing gymnastics' jumps split leap with and without throw-catch the ball. Five female gymnasts aged 12 to 15 years members of Tunisian national team of rhythmic gymnastics participated in this study. Every gymnast realized the split leap four times without apparatus and with apparatus. 2D motion analysis has been established to study the split leap with and without throw-catch the ball. The results show a significant variation of execution factors when introducing the apparatus such as the initial velocity, vertical displacement, the fly time, the component of vertical and horizontal force and the angular velocity of the split. When performing the split leap with apparatus, execution parameters show a significant decrease with the exception of the vertical velocity, acceleration and angular velocity of the split, which increase to compensate for the fall signs of strength and vertical displacement. Finally, the results showed also that probably gymnasts did not perform a jump with apparatus the best way that could.
gymnastics.

Keywords: *dual-task, split leap, throw-catch, force, speed, flexibility*

INTRODUCTION

Rhythmic gymnastics is an artistic sport, performed with technical apparatus (rope, hoop, ball, clubs and ribbon). Leaps are fundamental gymnast movements that require complex motor coordination of both upper and lower body segment (Ashby & Heegaard, 2002). To make it all more interesting and complex, leap performance is in most of the cases followed by a additional but required manipulation (ball, rope, hoop and ribbon) and that manipulation is referred to requisite throws or passing through it. That is why the capacity of performing in rhythmic gymnastics is very complex, since the gymnast is frequently facing dual-task situations: jumping, twisting or balance with starting or handling apparatus. Therefore, we cannot consider only the quantitative aspect, but also the quality of execution that depends directly on the level of coordination, technical mastery, and physical performance of the gymnast. Within this framework, we can confer to body strength, speed and flexibility, an important topic. However, these three parameters are not required in the same way depending on the readiness of the gymnast and the mode of execution of the exercise "simple or dual-task". Note that if the technical gesture is not automated during learning, early introduction of a second task may cause disruption in the execution of the first. In addition, neglecting the development of these physical abilities, affects negatively the optimal execution of the gesture when a second task is introduced. To combine many elements, a gymnast must have highly developed proprioception and motor control, obtained through neurological development, through years of practice. The neuromuscular system must coordinate movements, and very fine control is required, Brooks (2011).

In the literature, there are little researches till today that they have been addressed to the relationship between the deployment of the qualities of force, velocity and flexibility and the performance of gymnastics' jump with different levels of difficulty. Indeed, most research conducted in the field of gymnastics' jump, treat the biomechanical aspect (Manoni, 1986; Gross, Cova, Peura, & Samczyk, 1996; Rutkowska-Kucharska & Sikora, 1996; Sousa et Lebre, 1996 and 1998 ; Rodrigues, Rayes and Galàn, 2008; Cicchella, 2009; Purenović, Bubanj, Popović, Stanković and Bubanj, 2010; Sousa & Lebre, 2010; Abd El-Hammid, 2010). Physiological aspects and the effect of training, were treated by (Dyhre-Poulsen, 1987; Alexander, 1989; Pineau & Arbi, 1996; Hutchinson, Tremain, Christiansen and Beitzel, 1998; Di Cagno et al. 2008, 2009 and 2010). Researches related to motor control have been done by (Bodo Schmid, 1990; White & Hardy, 1995; Loquet, 1997; Micheles & Ruat, 1997; Kioumourtzoglou, Derri, Mertzanidou and Tzetzis, 1997; Miletić, Sekulié, and Wolf-Cvitak, 2004).

The aim of his research is to study the effect of a second task "throw-catch the ball" on the realization of a basic gymnastics' jump "split leap", to identify the different in the deployment factors of performance, particularly the strength, speed and flexibility, while throwing up the apparatus (Figure 1).

In this regard, we make the following assumptions: The success of the action would depend largely on the qualities of force-velocity and flexibility highly developed in specific aspect. On the other hand, the solicitation of these three factors of performance when carrying out the split leap would change significantly with the apparatus.

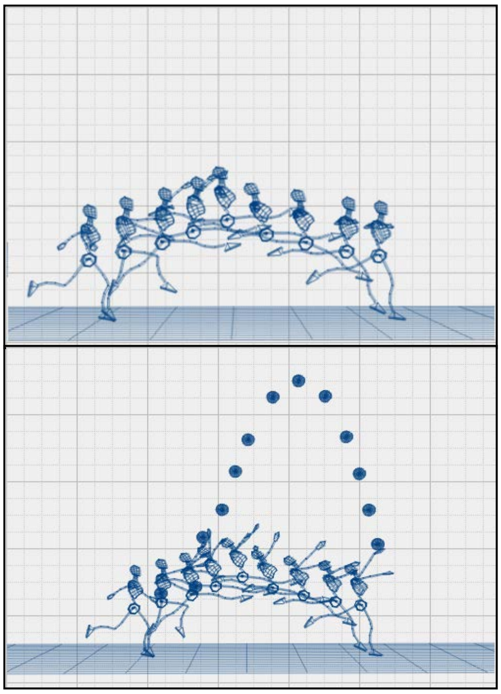

Figure 1. *Split leap with and without throw-catch of the ball.*

METHODS

Five female rhythmic gymnasts members of the Tunisian Junior National team (age 13.8 ± 1.3 years; height 1.58 ± 0.07 m; weight 46.59 ± 8.23 kg; training average 20 h / week) agreed to participate in this study. The experiment is performed in real conditions, on a floor of 12m x 12m. It is a two-dimension "2D"study based on a reference (O_x, O_y). The shooting was carried out by two cameras Sony DCR PC 105E, 1 megapixel CCD, 50 fps, 1 Lux minimum sensitivity, with wide conversion lens. The first one is placed in front at 3m on the diagonal of the floor, and the second in profile at 15m from the axis of progression of the gymnast (Figure 2).

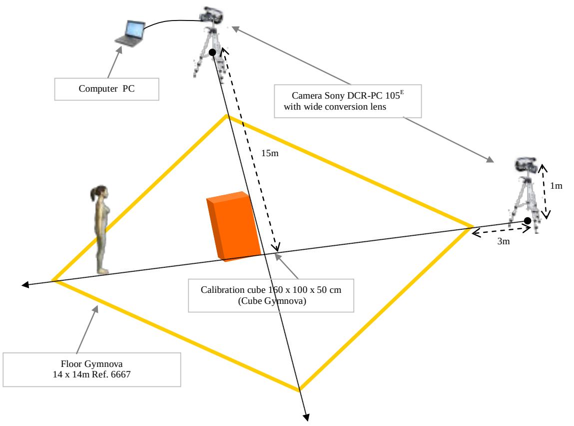

Figure 2. *Experimental device.*

During the first part of the experiment, each gymnast executes the split leap six times without apparatus separated by a two-minute recovery time. The second part consists of reproducing the same with apparatus. Only the best four trials were retained for the reproducibility analysis, and the best jump among the retained four is used for the comparative study.

We opted for the mono-segmental method of analysis (Thirunarayan, Kerrigan, Rabuffetti, Croce & Saini, 1996). Gymnasts were equipped with three markers: one on the hips (at 56% of the height) and two on the ankles to assess legs' split angular velocity. The geometrical center of the ball was also considered. Similarly, we adopted the ground and the center of gravity of the gymnast as a reference for study. To calculate the force generated during the pulse, we used the equations presented by Smith, (1983):

$$F_x = m \cdot \left(\frac{V_{xf} - V_{xi}}{t_i} \right)$$

and

$$F_y = m \cdot g \cdot \left(\frac{V_{yf} - V_{yi}}{t_c} \right)$$

* *Fx: horizontal force component, F_y: vertical force component, V_{xi}: initial horizontal velocity, V_{xf}: final horizontal velocity, V_{yi}: initial vertical velocity, V_{yf}: final vertical velocity, t_i: initial time, t_c: contact time, m: mass, g: gravity.*

The analysis of the movements is performed by AviStep® and Regressi® software. The construction of the kinograms realized through Poser® 4 software. For data analysis, SPSS® 13.0 Software was used. The normality of distribution estimated by the Kolmogorov-Smirnov test wasn't satisfactory for all variables. Therefore we used nonparametric tests: The Friedman Test is used to assess the reproducibility of gymnastics' jumps while the U test of Wilcoxon was applied to compare the two technical jumps. The results are considered significantly different when the probability is less than or equal to 0.05 ($P \leq 0.05$).

RESULTS

The reproducibility' study did not show any significant variation of the performance factors. All gymnasts were able to repeat the same movement with and without apparatus. However, performance factors when split leap is executed without apparatus (SLw) were significantly different from those when the split leap is executed with throw-catch of the ball (SLtc), (table 1).

Only the vertical velocity (Vy) and the angular velocity of the split (ωsl) increased significantly at ($p < 0.05$) during the (SLtc), [1.6 ± 0.1 m/s vs 1.5 ± 0.2 m/s for the (Vy) and 963.4 ± 11.2 deg/s vs 803.3 ± 20.3 deg/s for the angular velocity of the split respectively for the (SLtc) and (SLw)].

On the other side, all the other components decreased significantly: Peak power was significantly lower ($p < 0.05$) [1480.4 ± 217.9 W vs 1606.7 ± 291.6 W respectively for (SLtc) and (SLw)]. Force was also significantly lower [924.8 ± 82.2 N vs 1032.3 ± 125.6 N respectively for (SLtc) and (SLw)]. Indeed, we noticed a drop in the level of vertical force component of

107.52 N in (SLtc). In its turn, initial velocity significantly decreased [6.937 ± 0.973 m/s vs 7.971 ± 0.302 m respectively for (SLtc) and (SLw)]. Vertical displacement was also significantly lower [0.382 ± 0.02 m vs 0.4 ± 0.03 m respectively for (SLtc) and (SLw)].

Table 1. *Comparative study between the split leap and the split leap throw-catch.*

		Means	*Standard deviation*	*Z*	*Df*	*Sig,*
Horizontal Displacement d_x (m)	SL_w	2,059	0,109	-1,214	4	0,225
	SL_{tc}	1,856	0,321			
Vertical Displacement d_y (m)	SL_w	0,413	0,036	-2,023	4	0,045*
	SL_{tc}	0,382	0,027			
Initial Velocity v_i (m/s)	SL_w	7,971	0,302	-2,023	4	0,045*
	SL_{tc}	6,937	0,973			
Horizontal Velocity v_x (m/s)	SL_w	4,118	0,32	-0,674	4	0,5
	SL_{tc}	3,925	0,775			
vertical Velocity v_y (m/s)	SL_w	1,504	0,115	-2,023	4	0,045*
	SL_{tc}	1,600	0,154			
Horizontal Force Components f_x (N)	SL_w	47,173	11,204	-2,023	4	0,043*
	SL_{tc}	40,711	9,314			
Vertical Force Components f_y (N)	SL_w	1032,323	125,269	-2,023	4	0,043*
	SL_{tc}	924,802	82,175			
Peak Power p_y (W)	SL_w	1606,732	219,659	-2,023	4	0,045*
	SL_{tc}	1480,455	217,968			
Angle of Split α_{sl} (deg)	SL_w	185,22	3,766	-1,753	4	0,08
	SL_{tc}	180,630	4,165			
Angular Velocity of the Split ω_{sl} (deg/s)	SL_w	803,285	20,279	-2,023	4	0,043*
	SL_{tc}	963,408	11,492			

* Significant at $P < .05$

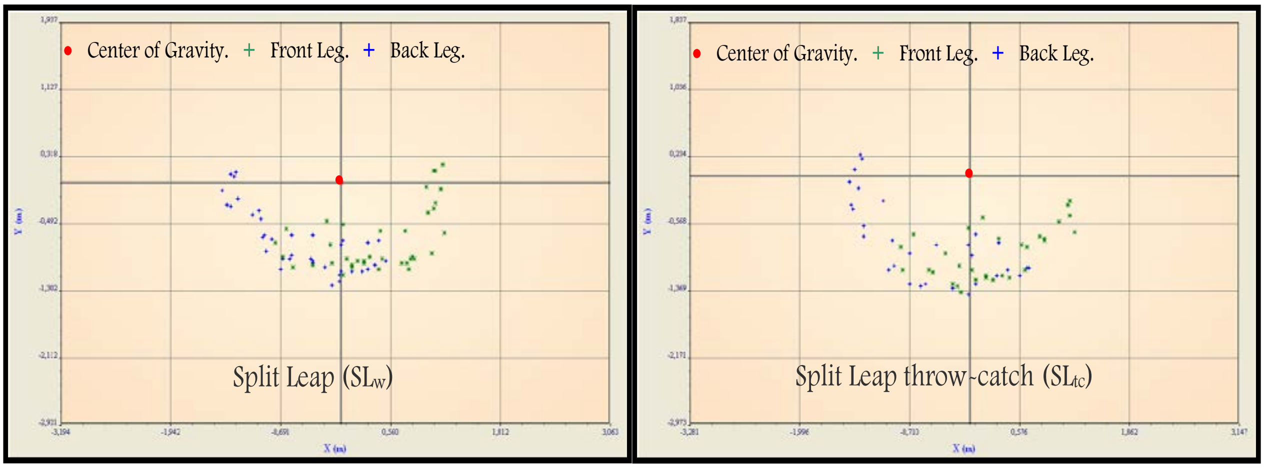

Figure 3. *Vertical displacement of the lower limbs from the Center of Gravity.*

The angle of split, decreased from 185.2° to 180.6° respectively for (SLw) and (SLtc) especially for the front leg, (figure 3).

DISCUSSION

Kinematic analysis of the split leap executed with and without throwing catch of the ball shows that the two jumps are different at the following levels in the preparation and takeoff phase and in arms swing during the flight phase and in landing. Results show that in the preparatory phase the initial velocity is greater for the jump executed without apparatus which is confirmed by the work of Sousa and Lebre (1996) and Abd El-Hamid (2010). Similarly the power and strength developed are more important than the jump with apparatus. This drop can be explained by a weakness in the lower limb strength since the tested gymnasts developed a relative strength fairly low compared with values published by Gross et al (1996), 20.2N/kg vs. 36.6N/kg respectively. Indeed, several authors have so far determined the positive influence of power dimension and the performance efficiency in rhythmic gymnastics (Wolf-Cvitak, 1984; Hume, Hopkins, Robinson and Hollings, 1993). Nevertheless the vertical velocity and speed of slit of the legs increase significantly during the SLtc. This raise in vertical velocity can be explained by the arm action when throwing while the speed of split of the legs is just a compensation for the decline of vertical movement in order to give more attention to the apparatus. According to Miletic et al. (2004), the highly pondered component in the performance evaluation of the SLtc, is related to the height of the leap jump executed. Thus, the correlation with the dimension of explosive-strength is embodied. Finally, this variation of executions factors during the in the split leap with throw-catch of the ball, can be linked to the blind landing by gymnasts since their eyes keep following the path of the ball which influences technical execution of the leap.

To summarize, we can attribute these differences in the deployment of qualities of strength, speed and flexibility to an important focus on the apparatus. The attention, which may seem necessary to perform a task, can have the opposite effects if it is too high and therefore block the correct implementation of a gesture as reported in Wallon (1959). Similarly, competition between resources of the two tasks can modify the motor performance. There are then a major task and a secondary task (Brisswalter and Legros 1996)

Accordingly, the obtained values and their variations indicate clearly that the gymnasts studied did not reach the level of automation required for optimum performance. In fact, the SLtc is among the most complicated element. A gymnast has to execute a very complex element, consisting of manipulation with the ball, then simultaneous leaping and throwing, which are followed by soft landing and synchronized ball catching.

Perfection in training is essential for a translation into a high performance. Improper training usually causes improper muscle recruitment and automatism. We recommend that during initiation on the gymnastics' jump with apparatus coaches should automate the jump and improve the physical quality of execution before introducing apparatus. Performance is seen as an image of training.

CONCLUSION

The main results of kinematic analysis performed in both jumping, show a significant variation of the following parameters: initial velocity, vertical displacement, strength (vertical and horizontal component), peak power and angular velocity of the split. The initial velocity on take-off was the kinematic parameter with more influence on the performance of the gymnasts during the execution of these jumps. The results showed also that probably gymnasts did not perform a split leap with throwing ball the best way that could.

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