Supplementary Issue: Winter Conferences of Sports Science. Costa Blanca Sports Science Events, 22-23 March 2021. Alicante, Spain.

Push up, explosive push up and free fall tests to evaluate the upper body power: A preliminary study in aerobic gymnastics

DANIELE ALBANO , CRISTIANA D'ANNA, RODOLFO VASTOLA

Department of Human, Philosophical and Educational Sciences, University of Salerno, Italy

ABSTRACT

Aerobic gymnastics is a competitive sport originating from traditional aerobics in which complex, high-intensity movement patterns and elements of varying difficulty are performed to music. A fundamental technique in this sport is the Push Up performed with different variations, in an explosive way and as a landing position from a jump. Given the importance of this technique and therefore of the strength of the upper limbs, the aim of this study is to apply the jump tests normally used for the evaluation of the lower limbs to the upper limbs. The study involved two gymnasts (age 16) Gold level of Italian Gymnastics Federation. Three specific tests have been performed: Push Up Jump Test (PUJT); Explosive Push Up Test (EPUT); Free Fall Test (FFT). Two force platforms were used to obtain the vertical component of the ground reaction force (GRF). Peak force (Fmax), rate of force development (RFD), symmetry index (SI), contact time (CT) and flight time (FT) were calculated. This type of analysis can provide useful information on the way in which the force is expressed by the upper limbs, furthermore the comparison between the two limbs can help to identify any asymmetries in pushing or in the management of the impact on landing. It is necessary to carry out further studies on a larger sample aimed at validating this type of test, however the information obtained can be used both to prevent injuries and to monitor and improve performance.

Keywords: Aerobic gymnastics; Push-up; Test; Force platform.

Cite this article as:
Albano, D., D'Anna, C., & Vastola, R. (2021). Push up, explosive push up and free fall tests to evaluate the upper body power: A preliminary study in aerobic gymnastics. *Journal of Human Sport and Exercise, 16*(3proc), S973-S979. https://doi.org/10.14198/jhse.2021.16.Proc3.13

Corresponding author. *Department of Human, Philosophical and Educational Sciences, University of Salerno, Italy.*
E-mail: dalbano@unisa.it
Abstract submitted to: Winter Conferences of Sports Science. Costa Blanca Sports Science Events, 22-23 March 2021. Alicante, Spain.
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2021.16.Proc3.13

INTRODUCTION

Aerobic gymnastics is the ability to perform continuous complex and high intensity aerobic movement patterns to music, which originates from traditional aerobic exercises (FIG, 2021). It is a combination of basic aerobic steps together with arm movements, to create dynamic, rhythmic, and continuous sequences of high and low impact movements (Chayun et al., 2020), all performed at an adequate level of intensity (FIG, 2021). The exercises are classified in four different groups (FIG, 2021), A (Dynamic Strength), B (Static Strength), C (Jumps and Leaps), D (Balance and flexibility). In Aerobic Gymnastics a fundamental technique is the Push-Up which is one of the difficulties of group A (Dynamic Strength), it consists in pushing with the arms with hands and feet in contact with the ground and body straight. Another fundamental technique is the Explosive Push-Up which involves the detachment of the hands from the ground and is the starting technique for other difficulties. The Push-Up represents a fundamental position since it is used as a starting or finishing position during the execution of other difficulties, in particular the Free Fall, belonging to group C (Jumps and Leaps) and consists in landing from a flight phase in Push-Up position. Strength in the upper limbs, therefore, is very important in Aerobic Gymnastics and in particular the strength expressed in this specific position. There are currently not many studies on upper limb strength in Aerobic Gymnastics, most studies have focused more on workload, cardiovascular effort (Alves et al., 2015) and injuries (Abalo Núñez et al., 2018; 2013a; 2013b; Núñez, 2015) resulting from practice, some that have analysed explosive strength have been conducted on the lower limbs through jump tests (Mihaela & Dragomir, 2021; Ol'ga & Erika, 2010). There are studies in the literature that have analysed the execution of the push up and its variants using strength platforms (Dhahbi et al., 2017a; 2017b; Waller, 2016; Koch et al., 2012; Ebben et al., 2011), even if not in relation to Aerobic Gymnastics. However, most of these studies focused only on the performance aspect and there is no research aimed at injury prevention through the execution of these tests. In any case, the evaluation of the push-up movement through force platforms seems to be valid and reliable (Parry et al., 2021; 2020; Bohannon et al., 2020; Zalleg et al., 2020; Gillen et al., 2018; Hogarth et al., 2013).

METHODS

Participants

The study involved two gymnasts, one male and one female, Gold level of Italian Gymnastics Federation, Junior B category (age 16). The female subject was 1.70 m tall and weighed 60 kg. The male subject was 1.77 m tall and weighed 73 kg.

Procedures

Two BTS P-6000 force platforms (BTS S.p.A., Italy) were used, with a sample rate of 1000 Hz according to Street et al. (2001). The vertical component of the ground reaction force (GRF) was analysed. Peak force (Fmax), rate of force development (RFD), symmetry index (SI), contact time (CT) and flight time (FT) were calculated. The parameters analysed were calculated for the push and landing phase, as resultant and for the right and left limbs. The athletes, after performing a general warm-up, performed three specific tests:

- Push Up Jump Test (PUJT): the elbows are flexed at 90° and the body straight, then the athlete pushes as fast as he can to detach the hands from the ground.
- Explosive Push Up Test (EPUT): body straight and elbows extended. The athlete does a countermovement with maximum elbow flexion of 90°, then he pushes as fast as he can to detach the hands from the ground.
- Free Fall Test (FFT): starting from standing position, the athlete falls forward with the arms extended in front of him, the feet don't move. At the landing, the elbows flex at 90° maximum, then the athlete pushes as fast as possible to detach the hands from the ground.

Figure 1. PUT.

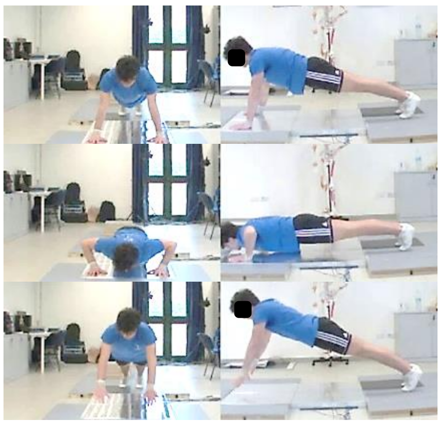

Figure 2. EPUT.

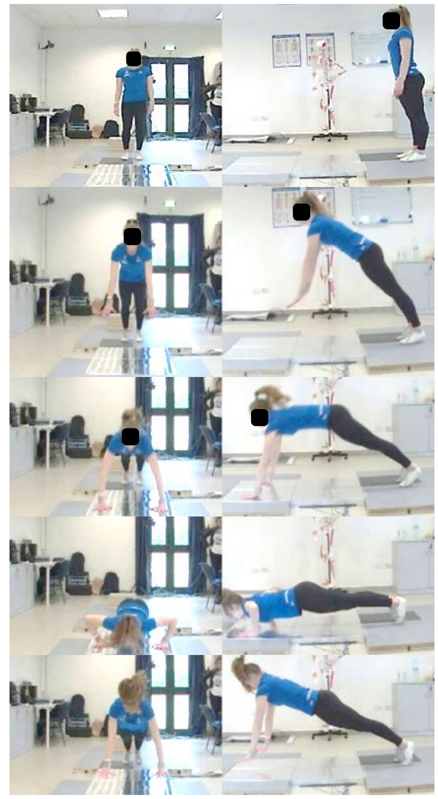

Figure 3. FFT.

Data analysis

The data were analysed using the SmartAnalyzer software (BTS S.p.A., Italy). The vertical component of the GRF (GRFv) was filtered with 2nd order Buttersworth low pass filter with a cut-off frequency of 580Hz, according to Street et al. (2001). Then, mass, acceleration and velocity were calculated to identify the different phases of the movement. The mass was calculated starting from the weight recorded on the platforms for a period of 1 s prior to the start of the movement (except for the FFT). The acceleration was calculated by dividing the GRFv by the mass obtained previously. The velocity was calculated from the acceleration through integration. To correctly identify the events of start, take-off and landing, thresholds were used. For the start of movement, a threshold equal to 5SD plus the average of the GRFv value, during the weighing phase prior to the start of the push, was used as recommended by Owen et al. (2014). A threshold equal to 5SD plus the average GRFv value recorded during the flight phase was used for take-off and landing (Chavda et al., 2018). The event of transition from eccentric to concentric phase was identified on the velocity-time curve, as the instant in which the value is equal to 0 immediately after the eccentric phase, characterized by negative values. Finally, the following parameters were calculated:

- Peak Force (Fmax): maximum value of GRFv in the push phase. Normalized on mass (N/kg);
- Rate of Force Development (RFD): the ratio between Fmax and time from the start of the push to the peak force. Normalized on mass (N/s/kg);
- Symmetry Index (SI): the ratio between Fmax of the left arm and the right arm (Impellizzeri et al. 2007);
- Contact Time (CT): time from the start of the push to take-off in seconds (s);
- Flight Time (FT): time from the take-off to landing in seconds (s).

RESULTS

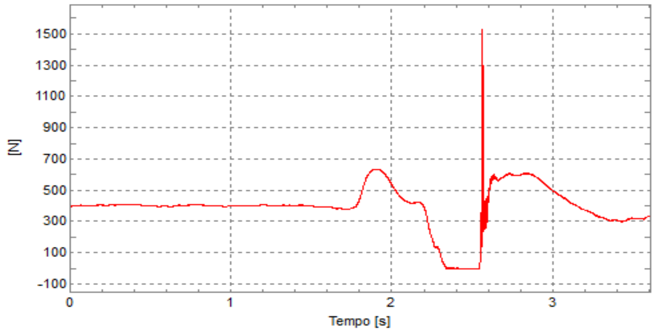

Figure 4. GRF vertical component in the Push-Up test.

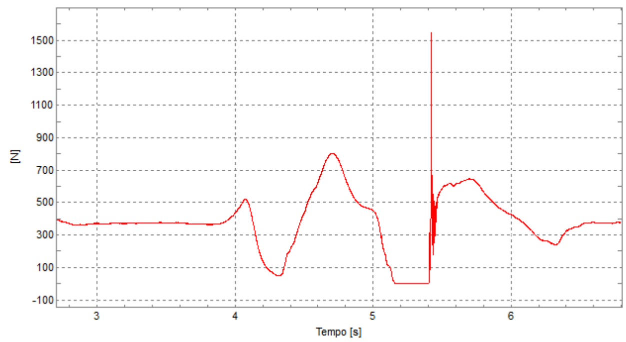

Figure 5. GRF vertical component in the Countermovement Push-Up test.

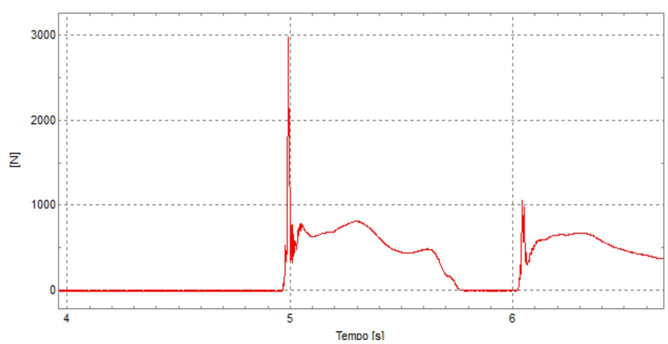

Figure 6. GRF vertical component in the Free Fall test.

Table 1. An example of computed parameters in the EPUT.

Explosive Push-Up Test				
Parameter	**Unit**	**Total**	**Right**	**Left**
Fmax	N/Kg	1.392	0.691	0.7
RFD	N/s/Kg	7.636	3.798	3.855
Symmetry Index (L/R)		1.099		
Contact Time	s	0.972		
Flight Time	s	0.28		

DISCUSSION

With the results from the three tests, it is possible to obtain various information on the neuromuscular characteristics of athletes. The PUT provides information on the athlete's explosive strength capabilities, through the RFD parameter. By having the force measurements from both limbs, it is possible to evaluate the symmetry in the push phase. The EPUT provides information on the athlete's ability to take advantage of the stretch-shortening cycle in the push performance. By having the force measurements from both limbs, it is possible to evaluate the symmetry in the push phase. The FFT provides information on the athlete's landing management and their ability to decelerate the fall, absorb impact and reverse movement by pushing upwards. By having the force measurements from both limbs, it is possible to evaluate the symmetry in the landing and subsequent push phase. A marked asymmetry during landing could generate an overload on one of the two limbs and lead to injuries. The SI indicated as the ratio between the peak force of the left with respect to the right will therefore be 1 if the push is perfectly symmetrical, >1 if the left is greater than the right and <1 if the right is less than the left. Due to the limited sample and the short term of the study, we cannot know the degree of asymmetry directly related to the increased risk of injury.

CONCLUSIONS

In this study, the use of force platforms was proposed to evaluate three fundamental exercises in Aerobic Gymnastics, the Push-Up, the Explosive Push-Up and the Free Fall. Three tests PUT, EPUT and FFT have been proposed, which can provide important information both from a performance point of view and from the point of view of injury prevention. The study is configured as a pilot study and therefore it is necessary to carry out further research on a larger sample to validate the use of the three tests proposed for the assessment of performance in Aerobic Gymnastics athletes.

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