NEW TOOL TO ASSESS THE FORCE PRODUCTION IN THE SWALLOW

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Abstract

8 men artistic gymnasts were evaluated with a new test protocol in order to assess isometric strength in an specific hold position on still rings. The proposed test protocol measures the force applied the gymnast on the rings from an initial lying prone position on a force platform while he is trying to achieve the Swallow (or Hirondelle) position. The vertical force (FZ) from the forcetime curve registered (100 Hz) was used and it showed a descent from the initial body weight level caused by the gymnast force on the rings and, later, a maximal isometric force period. Fundamental and derivate variables to extract from the evolution of Fz were defined. Results showed significant statistical differences between gymnasts that could perform the Swallow (P) from those that could not (NP) ($p<0.05$). Performer gymnasts were characterized by a higher percentage of body weight descent and higher strength in relation to body mass ($p<0.05$). The practical application of this tool could be to provide coaches with information about how close the gymnast is to perform the Swallow.

Keywords: *Men's Artistic Gymnastics, Biomechanics, Rings, Swallow.*

INTRODUCTION

Measuring the athletes' performance is crucial to determine their progress and potential in any sport. The measurement and evaluation of the different components of performance is part of the training monitoring process, which aims to provide consistent information about the effects of the training load and the physical and technical condition of the athlete. This valuable information helps the coach to individualize the training process and provides the athlete with adjusted and individualized stimuli in order to obtain the optimum performance. Optimize and contextualize the evaluation of the athlete is necessary for a proper diagnosis and monitoring of the training (GonzálezBadillo & Izquierdo Redín, 2006).

Gymnast performance is not based in the objective measurement of distances, weight or times, but it depends on a subjective scoring of the judges. Therefore, competition results cannot be the single source of information to guide the work of the coach. However, during the training process, measurement of valid and objective quantitative variables as the force can provide both the athlete and coach, with helpful information about the progress made during the slow and limited teachinglearning process in rings. It would be useful for coaches and gymnasts to know how close or far that is the gymnast from performing static force elements in order to focus the training on a selected element due to the proximity of the gymnast to the levels of force required to perform it, or to abandon the idea of perform the element because this level of force is not possible to acquire by the gymnast in short-term (Dunlavy et al, 2007).

There are several studies that attempt to analyse the variables with a greater impact on the gymnast's performance. Back in the '60s, Pool, Binkhorst & Vos (1969) related the anthropometric and physiological data of female artistic gymnasts with their performance at the European Championships in 1967, indicating significant correlations between the chest circumference and the total score. In this sense, Sharma & Nigam (2010) indicate no relationship between physiological variables such as heart rate and blood pressure with the performance in competition for college male and female artistic gymnasts. On the other hand, Grande et al. (2008) found correlations between the legs power measured using jump test and "D" and "E" scores on different events in high level artistic female gymnasts.

Leon-Prados et al. (2011) found interesting correlations between different variables recorded by specific physical test in men and performance in parallel bars, high bar and pommel horse. These authors showed how the maximum number of repetitions to Swiss press from L-sit showed a significant correlation with the gymnast performance of parallel bars ($r=0.825$, $p<0.05$) and high bar ($r=0.678$, $p<0.05$).

Despite these references, to measure and evaluate the athlete during the training process and the validity of that information in order to guide the coach work is still an open field for researching and innovation.

Along the learning process of any element, it would be very useful for coaches to have a tool which allowed determining the gymnast level of assimilation or learning in any specific technical element to focus the gymnast on weakness points in order to accelerate progress towards more advanced elements. This fact is specially emphasized in the still rings event and especially in the strength and maintenance difficulties (Group IV, Code of Points - Men's Artistics Gymnastics) (FIG, 2009). One of the disadvantages of the training process of these difficulties is that information on the progress and potential of the athlete are absolutely unknown along the period of preparation of the gymnast (Sands, Dunlavy, Smith, Stone, McNeal, 2006).

If we focus on the studies carried out in still rings, most of them are developed in the field of biomechanics, and they applying three methods of analysis: photogrammetry, electromyography and force platforms. Based on the analysis mathematical simulation of human motion applications, multiple studies have been conducted on this event. Sprigings et al. (1997) showed that using computer simulation can help to reduce intermediate rings swings between the long-swing elements. By using a combination of photogrammetry and tensionmetric gauges, Brewin et al. (2000) demonstrated that the changes in the technique and flexibility reduced force peaks on the gymnasts' shoulders while they performed long-swings. Yamada et al. (2002) developed a simulator robot of long-swing elements in the still rings.

Moreover, the contributions of electromyography (EMG) have been conducted primarily at determining the specific muscle groups involved in performing a particular difficulty and the ability to reproduce patterns of actions through facilitated positions. Bernasconi et al. (2004) found significant differences in muscle coordination in the performance of cross in rings with and without forearm support devices. Bernasconi et al. (2009) differentiated specific muscle coordination for three different Swallow (or Hirondelle) training methods. Campos et al. (2011) demonstrated that the coordinated action of the biceps and triceps, serratus anterior, lower trapezius, pectoralis major, latissimus dorsi, anterior deltoid and the infraspinatus is responsible for the successful completion of the Swallow.

Studies that used the force platform in gymnastics are very specific and they study variables related to balance, proprioception and strength on hold positions. Vuillerme et al. (2001) showed that the gymnasts are able to use remaining sensory capabilities to compensate the lack of vision in unstable positions.

Dunlavy et al. (2007) used force platforms to assess the force performance on simulated rings cross positions. This work was based on a clear premise: to achieve the holding of a strength hold position on rings, the gymnasts must be able to produce, in that specific body position, a level of force equal to or greater than their own body weight. Under this premise and applying it to the Cross position (Element 14, Group IV, Difficulty B) (FIG, 2009), these authors conducted a study simulating the execution of this element over two force platforms located on two supports. This analysis demonstrated that the sum of the recorded data by both force platforms was sufficiently accurate to distinguish between gymnasts “performers” and “no performers” of this element.

This latter approach is the framework of our work, in this case applied to Swallow element (Figure 1), which is a support scale maintained at rings height for at least two seconds (Element 10, group IV, Difficulty D) (FIG, 2009). In the technical implementation of the Swallow, commonly called butterfly, the body must show a position parallel to the ground, while the upper extremities are in the same horizontal plane with a slight shoulder abduction (García Carretero, 2003). The upper extremities, trunk, lower limbs and the lower part of the rings must be maintained in the same horizontal plane for the perfect execution of the element.

This element was selected because is a very common element that the vast majority of high level international gymnasts have in their competition routines.

Figure 1. *Gymnast performing a Swallow in still rings.*

Developing a measurement tool of this specific capacity of force applied to each still rings strength hold position, determining the minimum amount of strength required for a correct execution and, consequently, to have a tool to predict when an element may be ready for inclusion in a competition routine, it would be helpful to improve individualized technical learning plans for each gymnast on this event.

The main aim of this study was to develop a tool for measuring specific strength production of the gymnast performing the Swallow in the still rings, using a single force platform.

Associated with this main target several secondary objectives were established: (1) defining the specific variables analysis of element, (2) testing the reliability of the measurements with this tool, (3) determining the ability of tool to discriminate between performers and no performers gymnasts on this element and (4) determining the minimum level of force required by the athlete to run this strength hold position.

METHODS

Instruments

To develop this measurement tool, a portable force platform (FP) Kistler Type 9286B forces (Kistler, Switzerland) which records the three force components (Fx, Fy and Fz) was used. Only the vertical force values (Fz) were used at a sampling frequency of 100 Hz. BioWare software was used for recording measurements of force (N) respect to time (s). Training still rings adjustable in height, a plinth with a solid top surface and weighted belts (79.5 N) were used as supplementary material.

For the test, FP was placed on the plinth (height 62 cm). A structure of wood and metal was located on top of the plinth to achieve stability and robustness to support FP. This material placement brought up similar conditions to the completion of the element (sensation of suspension at a height above the ground) and prevented the athlete hit the floor with the rings or the lower limbs, something that was observed during the implementation of the pilot trials.

A fitness bar with two discs on each side with a total weight of 367.76 N was placed between the rings to adjust the height of them, to generate sufficient tension in the cables and to serve the horizontal reference between the FP surface and the upper edge of the lower part of the rings (Figure 2).

Figure 2. *Detail of the height adjustment of the rings and material setting*

The FP was calibrated with the additional weight carried by the gymnast. Thus, when the gymnast was located on the FP with the extra weight, only the weight of the gymnast was recorded. Measurements of the noise recorded by the platform on the floor and at the selected high were done, and no statistical differences were found between both situations.

Procedures

To perform the test, the gymnast lay in prone position on the FP, wearing the weighted belt, with the abdomen in the central part. The weighted belts were used for preventing elevation of the gymnast over the FP and losing the record of vertical force (Fz) during the whole test.

The gymnast adjusted his grip on the rings and placed in a comfortable position without touching any part of his body in other surface than the FP and the rings.

When the gymnast confirms he was ready, he began the test without making force on the rings. After a previously known beep, he applied an explosive force on the rings to achieve the position in the shortest time possible (i.e. avoiding performing a maximum isometric strength slowly and gradually). The gymnast was previously instructed to keep the element indicated for a minimum of 5 seconds (González Ribas-Badillo & Serna, 2002).

The test was aborted and repeated if the gymnast got in contact with any part of his body a surface different to the FP or the rings during the test.

Three attempts were recorded for each gymnast (González-Badillo & Gorostiaga Ayestarán, 1995) with a rest period of approximately 3-5 minutes between each attempt (Zatsiorski, 1982). The average of the three records obtained from each gymnast was used for the presentation of results and statistical calculations.

The recording time for each trial was programmed scheduled in 10 seconds. During that time, three phases were distinguished:

- Phase 1. *Body weight baseline record*. Recording time about 3 seconds before the beep tone, in which the gymnast was in lying prone position without applying force. The record is a horizontal line corresponding to approximate body weight of the gymnast (Figure 3).

- Phase 2. *Force explosive phase*. After the signal the gymnast applied an explosively force on the rings. Is reflected in the graph F / t as a descent steep slope corresponding to the time of release from the gymnast body weight.

- Phase 3. *Isometric force phase*. The gymnast performed strength levels close to his maximal isometric force (MxIF) values and try to maintain this level for 5 seconds. Graph shows an almost horizontal line around the value 0.

Figure 3. *Starting position and grip of the gymnast on the FP*.

The tests were performed during a regular training session at the High Performance Centre (CAR) of the National Sports Council (CSD) in Madrid after a 20 minute warm-up, with exercises appropriated to this kind of effort.

Participants

Eight gymnasts from the Men's Artistic Gymnastics (MAG) Spanish National Team voluntarily implemented the proposed test (Table 1). Subjects were informed of the nature and details of the test run, signing an informed consent which was approved, as the rest of the study, by the ethics committee of the Technical University of Madrid (UPM).

Participants were divided into two groups for analysis of the results. Group 1: Gymnasts Performers of the Swallow (n= 4). Group 2: Gymnasts No Performers (n= 4).

	Age (years)	Height (m)	Body weight (N)
Group (n=8)	20,5±4,4	1,68±5,67	646,33±63,1
No Performers (n=4)	17±1,2*	1,71±0,05 *	662,25±71,5
Performers (n=4) *	24±3,6*	1,65±0,05 *	630,41±51,6

Table 1. Features of age (years), height (m) and body weight (N) of the sample expressed in Mean ± SD (* $p < 0.05$).

Variables

The variables selected were divided into two groups:

a. General or fundamental variables (Figure 4):

- Slope (S): Slope of the F/t curve in the first 100 ms of application of force. The starting point of the application of force was established in the first instant that there was a continuous decrease of the curve F/t. The slope recorded in a given time period has been used in other studies as in the case of Willson et al. (1993) and Christ et al. (1994).
- Maximal Isometric Force (MxIF): It was the lowest recorded force value due to the release of the weight due to the effort of the gymnast.
- Mean Isometric Force (MnIF): Mean isometric force calculated for the period of 2 seconds with a lower standard deviation (higher stability of the strength). This period of two seconds was selected based on MAG Code of Points criteria for a properly maintained hold position on still rings is properly maintained (FIG, 2009). Dunlavy et al. (2007) used this variable in their study, although the selection criteria of the time interval were different.

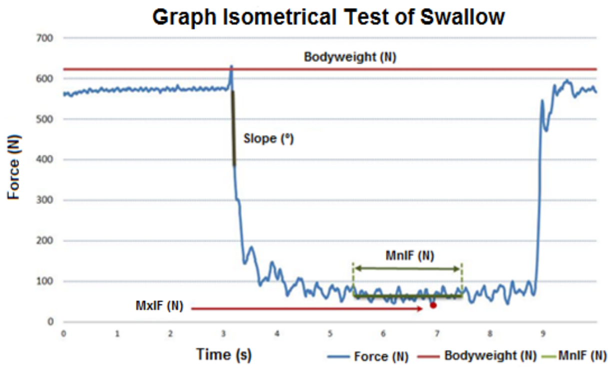

Figure 4. *F/t graph locating fundamental variables: Slope (S), Maximal Isometric Force (MIF) and Mean Isometric Force (MnIF).*

b. Specific or derived variables: two groups of variables are defined to be calculated based on the MxIF or MnIF:

b.1. Variables calculated from the value of MxIF:

- Absolute Released Force (MxIF-ARF): Difference between the gymnast body mass (N) and the MxIF (N). This reflects the total of the gymnast strength of about MxIF.
- Percentage of Released Force (MxIF-%RF): Percentage value (%) of MxIF-ARF by bodyweight of the gymnast.
- Relative Released Force (MxIF-RRF): Relationship established between the MxIF-ARF (N) and the value of the gymnast mass (kg). This reflects the strength capacity of the gymnast per body mass relative to MxIF. It is measured in N * kg^{-1}.

b.2. Variables calculated from the value of MnIF :

- Absolute Released Force (MnIF-ARF): Difference between gymnast body mass (N) and MnIF (N). This reflects the total strength of the gymnast regarding MnIF.
- Percentage of Released Force (MnIF-%RF): Percentage value (%) of the value MnIF-ARF (N) by bodyweight of the gymnast.
- Relative Released Force Unleashed (MnIF-RRF): Relationship established between the MxIF-ARF (N) and the value of the gymnast mass (kg). This reflects the strength capacity of the gymnast per body mass relative to MnIF. It is measured in N * kg^{-1}.

Statistical Analysis

Were calculated descriptive statistics (mean, minimum, maximum and standard deviation) of the variables of age, height and bodyweight of the sample used and the defined variables of strength tests performed.

An analysis of the reliability of the measurements obtained from the variables was performed by calculating the Intra-class Correlation Coefficient (ICC) and the Coefficient of Variation of the Standard Error of Measurement (CV_{SEM}), (Leon-Prados, Gómez-Piriz, and González-Badillo, 2011).

U of Mann-Whitney was run used to assess the statistical differences of the variables of the strength test between groups of gymnasts NR and R.

The minimum statistical significance was set at p=0.05 for all statistical tests.

Collection and calculation values of the variables were performed using a Microsoft Office Excel 2010 sheet. For statistical analysis of the results SPSS software version 18 was used.

RESULTS

Table 1 shows the characteristics of the eight gymnasts in this study (4 P and 4 NP of the Swallow). P gymnasts showed a mean age of 24±3.7 years, height of 1.65±0.05 m, and body mass of 630.4±51.6 N, and NP Gymnasts a mean age of 17±1.27 years, height of 1.71±0.05 m, and body mass of 662.2± 71.5 N.

The results of the analysis using the nonparametric U of Mann-Whitney test showed that age (Z=3.753, $p<0.001$) were significantly higher for gymnasts P and height (Z=2.10, p<0.05) significantly higher for NP. While the bodyweight was not significantly different between P and NP (Z=1.05, p=0.32).

Table 2 shows the overall results for fundamental and derived variables selected on the study.

Table 2. *Overall results for fundamental and derived variables.*

	Mean	Standard Deviation	Minimum	Maximum
Slope (º)	86,31	5,07	68,92	88,77
MxIF (N)	81,39	88,21	-50,37	171,30
MnIF (N)	122,35	86,71	-16,54	223,58
MxIF-ARF (N)	564,94	109,86	762,27	360,07
MxIF-%RF (%)	75,75	7,46	62,50	85,89
MnIF-ARF (N)	523,98	106,90	728,44	340,86
MnIF-%RF (%)	80,90	12,85	58,97	103,59
MnIF-RRF ($N * kg^{-1}$)	7,93	1,26	5,78	10,15

Table 3. *Study of reliability through the Intraclass Correlation Coefficient (ICC) and the Coefficient of Variation of the Standard Error of Measurement (CVSEM) for MxIF- ARF (N), MxIF-%RF (%), MIF-RRF (N * kg-1), MnIF- ARF (N), MnIF-%RF (%) and MnIF-RRF (N * kg-1).*

	ICC	CV_{sem}(%)	p
MxIF-ARF (N)	0,993	3,82	< 0,01
MxIF-%RF (%)	0,988	3,14	< 0,01
MxIF-RRF ($N * kg^{-1}$)	0,988	3,14	< 0,01
MnIF-ARF (N)	0,995	4,00	< 0,01
MnIF-%RF (%)	0,992	3,24	< 0,01
MnIF-RRF ($N * kg^{-1}$)	0,992	3,24	< 0,01

Table 4. *Results for fundamental variables and derived variables used in the study differentiating by groups (* p <0.05).*

	Group	Mean	Standard Deviation
Slope (º)	P	87,25	2,18
	NP	85,38	3,58
MxIF (N)	P	5,62 *	37,91
	NP	157,16 *	37,54
MnIF (N)	P	48,11 *	45,70
	NP	196,60 *	27,47
MxIF-ARF (N)	P	624,69	93,22
	NP	505,09	99,60
MxIF-%RF (%)	P	98,75 *	5,65
	NP	75,75 *	8,05
MxIF-RRF (N * kg^{-1})	P	9,68 *	0,55
	NP	7,42 *	0,79
MnIF-ARF (N)	P	582,30	102,44
	NP	465,66	84,27
MnIF-%RF (%)	P	91,86 *	7,54
	NP	69,93 *	6,18
MnIF-RRF (N * kg^{-1})	P	9,00 *	0,74
	NP	6,85 *	0,61

Table 3 shows the results of the reliability analysis for the measures of the variables obtained by the Coefficient of Variation of the Standard Error of Measurement (CV_{SEM}) and Intra-class Correlation Coefficient (ICC).

The reliability analysis results showed CV_{SEM} values below 5% for MxIFARF, MxIF-%RF, MxIF-RFU, MnIF-ARF, MnIF-%RF and MnIF-RFU, being these variables also among those that did not differ significantly between trials with high rates of ICC.

Differentiated results for P and NP regarding the selected fundamentals and derived variables are shown in Table 4.

The results for MxIF-ARF (Z=1.73, p=0.11) and MnIF-ARF (Z=1.44, p=0.20) showed not significant differences between NP and P. While results for MxIF, MnIF,

MxIF-%RF, FIM-RRF, MnIF-%RF and MnIF-RFU were significantly different between P and NP (always Z=2.31, p<0.05). The calculated value of slope showed no statistically significant difference between NP and P (Z=0.87, p=0.49).

DISCUSSION

As it has shown in the methods section, we have developed a tool for measuring specific isometric force to perform the Swallow in MAG still rings, which requires a single portable force platform for assessing the availability or possibilities of the gymnast to perform the element. The evaluation methodology applied to this element can be adapted to other positions of strength hold in rings and it could have multiple applications for controlling the training of gymnasts.

As positive aspects of the proposed tool, it should be noted that it can be used in the training hall and during the training process. The information provided by the proposed protocol cover the requirements of the coach for knowing the degree of assimilation of the technical element that the gymnast is learning.

For example, a NR gymnast with lower strength levels and a weight 557.65 N was able to release on the force plate a MxIF of 360.05 N, which is a 65% of his weight and a relative force to his weight (MxIF-RRF) of 6.33 N * kg^{-1}.

Considering the mean force during 2 seconds (MnIF) of 340.86 N, which is a 61% of his weight, and a MnIF-RRF of 5.99 N * kg^{-1}. In order to correctly perform the Swallow, the gymnast should reach a MxIF until 557.65 N (100% of his weight) by increasing his maximum strength or reducing his weight (something impossible because he is a very light gymnast); in that way he will improve his currently poor MxIF-RRF above 9 N * kg^{-1}. Increasing his maximum strength levels will probably elevate his levels of MnIF and MnIF-RRF until 90% of his weight and close to 9 N * kg^{-1}, respectively, which are the values obtained by the P gymnast.

As weak negative points, it can be pointed out that: (1) the use of the software for data collection and the interpretation of the data requires an appropriate training, (2) The information is not provided real time; in order to achieve the defined variable values an specific data processing of the collected data is required, so that, the information cannot be used as instant feedback for the gymnast. However, this is a research work, and its results and conclusion can be in future implemented by a software that automatically establish the fundamental and derived variables and provide the coach and gymnast with a real-time feedback.

Definition of variables

Associated with the protocol definition of test execution valuation, general (i.e. MxIF, MnIF and S) and specific variables (MxIF-ARF, MxIF-%RF, MxIFRFU, MnIF-ARF, MnIF-%RF and MnIF-RFU) have been defined. These latter variables are more useful for specific evaluation of gymnast and they can help determine the degree of assimilation of the analysed element.

The application of the proposed protocol in two groups of gymnast characterized by the performance or non-performance of the Swallow showed interesting results. The groups have different ability to apply force and release bodyweight of the force platform in specific the test. This was evident in the statistically significant differences found in multiple variables: MxIF, MnIF, MxIF%RF, MxIF-RFU, MnIF-%RF and MnIF-RFU.

The analysis of the slope of curve F/t in the first 100 milliseconds of force application showed no statistically significant differences between the two groups analysed. The analysis of this slope did not provide useful information for the coach so it seems not recommended for controlling the improvement in this element. In agreement with our results regarding the limited information provided by the rate of force development, González-Badillo & Ribas Serna (2002) indicated that this variable is the less reliable of all that can be extracted from an isometric measurement.

González-Badillo & Izquierdo Redín (2008) indicated that one factor to consider during an isometric test is the characteristics of the instructions provided to the subject. This test differentiates a progressive from explosive muscle activation. Sahaly et al. (2001) indicate that the instruction modifies the gymnast transmitted force production per unit time (RFD), so we will not get the same result if the instruction is "as fast as possible" than if is indicated "as hard and fast as possible”. In our case we select the protocol with rapid muscle activation for two reasons: first, to try to be closer to the nature of gymnast effort on rings, which is not possible a progressive activation and, second, to calculate the slope of the F/t curve a possible indicator of the RFD.

We should also highlight that the variables MxIF-ARF and MnIF-ARF do not reach statistically significant differences between groups of P and NP gymnasts. Using this protocol, the absolute value of the released weight would not be a valid variable to predict the execution of the Swallow in male gymnastics.

P gymnasts are characterized by generate a significantly greater percentage of force considering their body weight with values of 98.75 ± 5.65% for the MxIF-%RF and 91.86 ± 7.54% for the MnIF-%RF with significant higher values on these two variables for the P gymnasts.

Other Important variables that showed significant differences between P and NP, were the relative values of strength in case of both MxIF-RRF and MnIF-RRF. These variables define the ability to generate force possessed by gymnasts per body mass (Arkaev & Suchilin, 2004).

Using our tool, variables expressed in percentage or relative values would be more valid as a predictor of execution of the Swallow. This agrees with the recommendation of expressing the variables as a relative to the bodyweight value (Ariza, 2004) in their work oriented to gymnast prediction performance.

Reliability and objectivity

The reliability analysis of repeated measures on more than one occasion shows no significant differences between trials, showing high values of CV_{SEM} and ICC always below 5%, indicating internal consistency between measures.

The test protocol has been described in detail so that it can be replicated by other researchers; this point has to be verified in order to probe its objectivity. Analysing the reproducibility of the proposed tool may be purpose of future studies

P versus NP

According to the characteristics of the sample, the gymnasts showed some differences which could affect the ability to apply force. This could be directly related to the age of the gymnasts, as the performers were significantly older than the non-performers. Similarly, the height would be inversely related to this capability and the performers show significantly lower stature to nonperformers. Regarding weight were not found significant differences between groups. However, these differences do not interfere with the ability of the protocol to discriminate between P and NP gymnasts.

The differences found between some variables support that the gymnast's ability to apply force is a key factor that we should be controlled to get information on how close or far is the gymnast to perform the Swallow on still rings.

Regarding the relative strength to bodyweight, performer gymnasts show a significantly better outcome in the test (MxIF-RRF: 9.68±0.55 N * kg^{-1}; MnIFRRF: 9.00±0.74 N * kg^{-1}). NP Gymnasts show significantly lower values for both variables (MxIF-RRF: 7.42±0.79 N * kg^{-1}; MnIF-RRF: 6.85±0.61 N * kg^{-1}).

Minimum level of force

As seen in the data obtained for MnIF (Table 4), although in the case of P the value for this variable is very close to the total release of body weight (48.11 ± 45.70 N), it decrease below the value 0 only in two gymnasts. The reason of not reaching values below 0 N (despite having four gymnasts R) could be the location of the weight added to the gymnasts. Being this weight located at the waist, this could result on a small change in the location of the centre of gravity that could modify the actual conditions of execution. Given this situation, it could be proposed a new study placing the added weight on the chest, with a weight –vest.

Another reason for not producing the full liberation of body weight on the execution may be the location of the still rings for proper execution of the element (i.e. whether or not the position of the performer gymnast height is at the level of grip rings or slightly off, which is a penalty).A biomechanical study of the location of the centre of gravity and the position of the gymnasts in relation to the grip of the rings could also provide with useful information in this regard.

This methodology could make way for future research of other static elements on still rings, for example, the still ring cross, a static position very frequently used in competitions and highly representative in gymnastics which has been investigated with other methods,.

Reach a release of the body weight close to 100% on this protocol calculated by the variable MxIF-%RF and exceed a value of 90% approximately in the case of calculating the variable MnIF-%RF could indicate that the gymnast has the required specific strength to perform this element.

On the other hand reaching a MxIF-RRF value greater than 9 N * kg^{-1} or a MnIF-RRF value close to 9 N * kg^{-1} may indicate that the gymnast has adequate force capacity to execute this element.

CONCLUSIONS

It has been designed a specific tool, using a single force platform, for the assessment and evaluation of the ability to generate isometric force applied to the Swallow in still rings.

The reliability of the measurements made with our protocol has been proved, obtaining similar results from several attempts for the prediction variables of successful execution of the Swallow.

They have been reported reference values for associated variables which may discriminate between Swallow performers and non-performers. Reaching a MxIF-%RF value close to 100% on this protocol and exceeding the MnIF-%RF value approximately of 90% could indicate that the gymnast has the required specific strength to perform the Swallow. On the other hand reaching a MxIFRRF value greater than 9 N * kg^{-1} or a MnIF-RRF value close to 9 N * kg^{-1} may indicate that the gymnast has adequate force capacity to execute this element.

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