RELATIONSHIP BETWEEN SWALLOW, SUPPORT SCALE AND IRON CROSS ON RINGS AND THEIR SPECIFIC PRECONDITIONING STRENGTHENING EXERCISES

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Abstract

International men's gymnastics has evolved rapidly on all six apparatus. On rings, strength elements are primarily determining. Various preconditioning strengthening exercises are performed routinely in training. However, the relationship between these exercises and the strength elements on rings, which would be of interest for coaches, are not well studied. The objective of this study was to investigate the correlation between strength in seven preconditioning exercises and performance of three important hold elements: Swallow, Support Scale and Iron Cross. Ten male gymnasts of the Swiss national team performed a 1RM test for each of the seven strength exercises and a maximum static hold of the strength elements on rings. A significant correlation was observed only between Swallow with the preconditioning exercises Swallow supine position (r: 0.71, p: 0.031) and Bench press (r: 0.71, p: 0.046); as well as between Support Scale and Swallow supine position (r: 0.69, p: 0.039). Iron Cross correlated highest with the Cross belt (r: 0.66, p: 0.051) and Bench press (r: 0.67, p: 0.069). Further, it was observed that a minimal 1RM of 73.4% body weight is needed for the exercise Swallow supine position in order to complete a hold of the element Swallow on rings. For execution of the element Support Scale, a 1RM of 67.4% body weight for the exercise Swallow supine position is needed.

***Keywords**:Gymnastics, 1RM, Swallow, Support Scale, Iron Cross.*

INTRODUCTION

In the past few years, men's gymnastics has evolved immensely. On all six apparatus, acrobatic elements are constantly becoming more spectacular; however, on rings, strength elements play the most important role (FIG, 2013). These strength elements are divided into hold elements that need to be held for at least 2 seconds (isometric muscle contractions) and different forms of lifting (concentric muscle contractions) and lowering (eccentric muscle contractions) (Dunlavy, 2007).

These elements require a high level of strength and in order to learn them, athletes employ facilitated versions of the actual elements on the rings (by being supported by the coach or using a pulley system which reduces the athlete's body weight) and by performing preconditioning strengthening exercises to achieve the optimal physical condition for the elements.

On the one hand, these preconditioning strengthening exercises should be closely related (Colombo, 1994; Starischka, 1978) to the actual element on rings and induce a large enough training stimulus. On the other hand, they should not be overly strenuous on the athlete's body, by producing large levers or joint torques.

While there are many preconditioning strengthening exercises for the elements swallow (S), support scale (SS) and iron cross (C), some of these cause pain for the athletes. In order to optimize an athlete's training, only effective exercises should be used for preparation. Hence, it is important to know which exercises have the greatest correlation with success on the respective elements on rings.

Unfortunately, the relationship between strength in the commonly used preconditioning strengthening exercises and for the ring elements has thus far not been studied. However, knowledge about such relationships could be interesting and helpful for coaches.

The aim of this study is to analyze the commonly used preconditioning strengthening exercises for the elements S, SS and C on rings and their actual effect on the execution of the elements on rings. Seven commonly used preconditioning strengthening exercises were selected and their effectiveness on the elements as well as their tolerability on the human body were investigated.

Main question is how strong is the relationship between the elements Swallow, Support Scale and Iron Cross on rings and the selected preconditioning strengthening exercises (Swallow supine position (S_{sup}), Swallow supine position-anteversion ($S_{sup\ ant}$), Swallow Machine (S_{mach}), Support Scale Stand (SS_{stand}), Cross Machine (C_{mach}), Cross Belt (C_{belt})and Bench-press (BP))?

We hypothesized that, due to similarities in body position, Swallow and Support Scale would correlate well with S_{sup}, $S_{sup\ ant}$ and S_{mach} and that Iron Cross would correlate well with C_{mach} and C_{belt}.

METHODS

Experimental Approach to the Problem

The study was designed to compare the performance of three important elements on rings with their respective preconditioning strengthening exercises. Three elements, S, SS and C, along with the preconditioning strengthening exercises S_{sup}, $S_{sup\ ant}$, S_{mach}, SS_{stand}, C_{mach}, C_{belt} and BP were investigated. The elements and exercises are explained more closely below. All preconditioning exercises are designed to train all three elements on Rings.

Subjects

All top-level male athletes in the Swiss national team who were not injured or suffering from pain in the upper extremities or back voluntarily took part in the study (n=10). Athletes were informed about all study procedures, which were approved by an ethics committee. Their age, height and body mass were 21.5 ± 2.5 years, 168.6 ± 4.5 cm and 65.0 ± 5.0 kg.

Procedures

The study was conducted on two separate days, with a two-day break in between. On the first day, subjects performed the elements S, SS and C on rings in a randomized order. Three days later the subjects performed with a 1RM-Test maximal single repetitions of the preconditioning strengthening exercises (S_{sup}, $S_{sup\ ant}$, S_{mach}, SS_{stand}, C_{mach}, C_{belt} and BP), also in a randomized order. Athletes' performance of S and SS were filmed from the side (camera at ring height), and C was filmed from the front, in order to evaluate execution.

The three rings elements were carried out with a special pulley-system, where the athlete's body weight can be increased by additional weight or decreased by a counterweight. If the athlete was able to hold the position for longer than three seconds they repeated the element with less counterweight or more additional weight, until they could just manage to hold the element for three seconds, which was the required duration for a valid hold. The real holding time was measured (by Video frames) from the moment that a correct, stable position had been reached until the athlete deviated from the hold position by more than 45°, as shown in figure 1 below. Athletes had a maximum of three attempts.

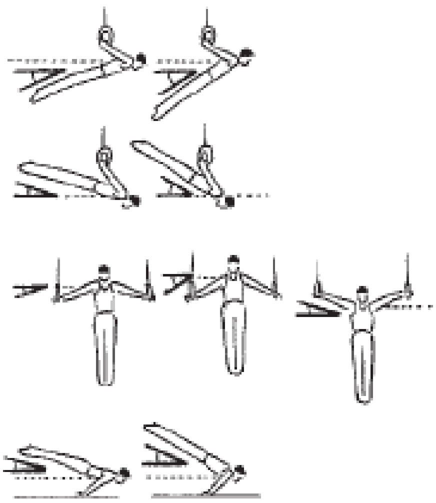

Figure 1. Deviation from the correct hold position was deemed and time stopped if these angles increased beyond 45° (FIG, 2013, p. 29).

For the preconditioning strengthening exercises, athletes had a maximum of three attempts to perform a correct repetition with the highest possible resistance (one week before, all subjects performed a preliminary test to determine their approximate 1 RM. This helped to minimize the number of attempts needed to achieve the true 1 RM in the actual trial). After each successful attempt, the load was increased with at least 2.5 kg (rest > 5 min).

Exercises were executed as follows:

Swallow supine position (figure 2 and 3)

- Material: bench, 15-kg barbell, weights.

- Starting position: supine on the bench, with the hands positioned on the bar one hand-width wider than the shoulders.

- Execution: flex shoulders lifting the bar vertically until arms are vertical (90 degrees) while maintaining contact with the bench with the back and head at all times.

Figure 2. Swallow supine position: starting position.

Figure 3. Swallow supine position: end position.

Swallow supine position, Anteversion (figure 4 and 5)

- Material: bench, at least 100 cm above the floor, weights, 10-kg barbell, two cables (16 cm in length) connecting the rings to the bar, 41cm from the center of the bar.

- Starting position: supine position with arms extended at 90 degrees holding the rings.

- Execution: flex the shoulders lifting the rings until the bar makes contact with the bench while maintaining contact with the bench with the back and head at all times.

Figure 4. Swallow supine position anteversion: starting position.

Figure 5. Swallow supine position anteversion: end position.

Swallow Machine (figure 6 and 7)

- Material: double cable-pull (two independent overhead pulleys) with ring attachments, three benches stacked on top of one another (total height 107 cm), 10 cm away from the machine.

- Starting position: prone on the bench, chin in contact with the bench, head not extend past the edge of the bench, arms extended behind the back.

- Execution: flex the shoulders pulling the rings downward while keeping the rings as close to the hips as possible until arms are vertical (90 degrees).

Support scale stand (figure 8 and 9)

- Material: wall, barbell and weights.

- Starting position: Standing with the back against the wall, bar held at shoulder width with a supine grip, feet one foot-length from the wall.

- Execution: Keeping the arms straight, flex shoulders lifting the bar until the arms are completely vertical and the bar is over the head, while maintaining contact to the wall with shoulders, head and lower back at all times.

Figure 6. Swallow machine: starting position.

Figure 7. Swallow machine: end position.

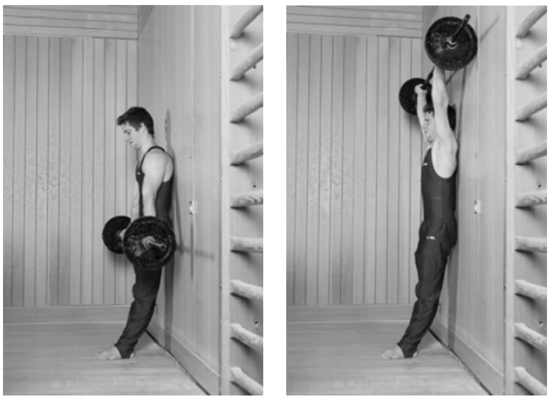

Figure 8, 9. Support scale stand: starting position, ending position.

Cross Machine (figure 10 and 11)

- Material: double cable-pull machine (two independent overhead pulleys) with ring attachments, 2 benches stacked on top of one another, placed as close as possible to the machine, with a 10-20 cm long mat on top.
- Starting position: sitting on the bench, with the arms abducted horizontally, and legs squeezing the bench (squeezing the bench with the legs is necessary to prevent the body from lifting during lifts with heavy loads.).
- Execution: adduct the arms pulling the rings downward towards the side of the body until arms are vertical (90 degrees).

Figure 10, 11. Cross machine: starting position, end position.

Cross Belt (figure 12)

- Material: rings, belt, loaded with additional weight or linked over pulley to counterweight (Bernasconi et al, 2006).
- Starting position: support sink.
- Execution: lower body into the cross position, hold for 2 s, lift body back into support sink position with straight arms.

Figure 12. Cross belt.

Bench press (figure 13 and 14)

- Material: Bench, barbell, weights.
- Starting position: supine on the bench, barbell held above chest with extended arms.
- Execution: gradually lower the bar until the elbows reach 90 degrees, await signal from coach, push the bar up until the arms are straight.
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Figure 13. Bench press: starting and end position.

Figure 14. Bench press: mid position.

Statistical Analyses

Descriptive statistics were run on all variables. Because of the small n, as often seen in investigation with elite athletes, Spearman's rho was used to assess correlations between hold elements and exercises. Correlation significance of was set to $p<0.05$. All statistics were performed using SPSS 22 software (SPSS, Inc., Chicago, IL).

RESULTS

Descriptive data from anthropometric measures, preconditioning exercises and rings elements are shown in tables 1 and 2. Table 2 displays the achieved weights, as well as the effective holding times, as not all subject achieved a holding time of 3 s exactly.

All athletes could perform C on rings, whereas only three managed to perform SS and only one could perform S, the most difficult element. The required holding time of 3 s was reached in most cases; thus, the calculations refer here forth only to the resistance (counterweight or additional weight) used for the elements.

Spearman correlation and significance between maximal resistance (counterweight or additional weight) for the elements S, SS and C on Rings and the 1 RM for preconditioning exercises is described in table 3.

Table 1

Anthropometric data of the subject pool and 1 RM of the preconditioning exercises Swallow supine position, swallow supine position – anteversion, Swallow Machine, Support Scale Stand, Cross Machine, Cross Belt and Bench-press in kg (n=10).

Athlet	Age	Body mass	Height	Swallow supine position	Swallow supine position anteversion	Swallow machine	Support scale stand	Cross machine	Cross belt	Bench press
		(kg)	(cm)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
1	20.9	65.0	168.1	35.0	25.0	34.5	23.0	52.0	-12.5	105.0
2	27.0	68.2	168.9	40.0	40.0	49.0	25.5	54.0	-7.5	130.0
3	20.7	61.4	170	32.5	35.0	42.0	23.0	49.0	-10.0	
4	21.6	62.6	162.5	35.0	32.5	39.5	25.5	51.0	-10.0	107.5
5	22.8	66.0	167.1	45.0	35.0	44.5	25.5	67.5	1.0	130.0
6	23.7	65.1	174.5	35.0	35.0	42.0	25.5	56.0	-5.0	95.0
7	19.3	74.4	174.1				25.5			
8	20.6	55.9	160.3	40.0	35.0	39.5	23.0	56.0	-5.0	115.0
9	19.5	62.0	169.8	22.5	22.5	27.0	20.5	44.0	-11.3	95.0
10	18.4	69.3	170.2	37.5	35.0	46.5	18.0	51.0	-7.5	120.0
Mean	21.5	65.0	168.6	35.8	32.8	40.5	23.5	53.4	-7.5	112.2
SD	2.5	5.0	4.5	6.3	5.5	6.6	2.6	6.5	4.1	14.0

Table 2

Achieved weights (counterweight or additional weight) in kg and holding times in s for the elements Swallow, Support Scale and Cross on Rings (n=10).

Athlet	Swallow		Support Scale		Cross	
	weight 3"	time 3"	weight 3"	time 3"	weight 3"	time 3"
1	-17.5	3.3	-10.0	3.6	0.0	3.1
2	-7.5	3.7	-8.8	3.6	3.0	2.3
3	-11.3	1.5	-7.5	3.1	6.0	2.5
4	-7.5	4.3	0.0	3.6	4.0	3.8
5	-7.5	3.7	1.0	2.9	8.0	3.9
6	-17.5	4.2	-10.0	2.8	1.0	3.0
7			-5.0	2.2		
8	0.0	3.1	1.0	3.6	7.0	3.5
9	-25.0	3.9	-17.5	3.1	0.0	3.5
10	-12.5	3.4	-5.0	2.2	1.0	3.0
Mean	-11.8	3.5	-6.2	3.1	3.3	3.2
SD	7.4	0.8	5.9	0.5	3.1	0.6

Table 3
Spearman correlation (r) and significance (p) between maximal resistance (counterweight or additional weight) for the elements Swallow, Support Scale and Iron Cross on Rings and the 1 RM for preconditioning exercises Swallow supine position, Swallow supine position – anteversion, Swallow Machine, Support Scale Stand, Cross Machine, Cross Belt and Bench-press (n=9).

		Swallow supine position	Swallow supine position – anteversion	Swallow Machine	Support Scale Stand	Cross Machine	Cross Belt	Bench-press
Swallow weight 3s	r	0.71*	0.56	0.38	0.42	0.48	0.54	0.71*
	p	0.031	0.117	0.31	0.259	0.186	0.134	0.046
Support Scale weight 3s	r	0.69*	0.39	0.34	0.24	0.46	0.60	0.7
	p	0.039	0.304	0.372	0.508	0.215	0.085	0.056
Iron Cross weight 3s	r	0.58	0.52	0.38	0.42	0.48	0.66	0.67
	p	0.099	0.147	0.317	0.255	0.188	0.051	0.069

* Significant at the 5% level ($p<0.05$)

Table 4
Spearman Correlation (r) and significance of the maximal strength (counter or additional weight, hold time 3 s) for three elements on Rings Swallow, Support Scale and Iron Cross (n=9).

		Swallow weight 3s	Support Scale weight 3s	Iron Cross weight 3s
Swallow weight 3s	r		0.87**	0.86**
	p		0.002	0.003
Support Scale weight 3s	r	0.87**		0.87**
	p	0.002		0.002
Iron Cross weight 3s	r	0.86**	0.87**	
	p	0.003	0.002	

** Significant at the level of $p < 0.01$

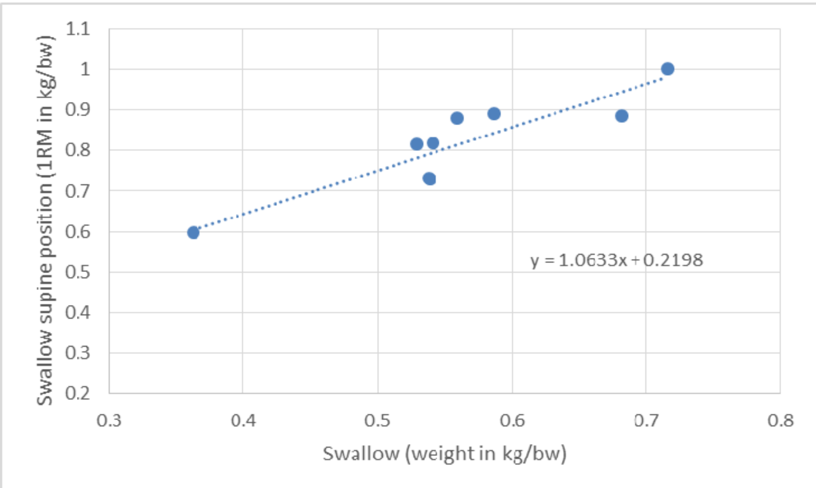

Figure 15. Correlation between maximal resistances for the preconditioning exercise Swallow supine position (1RM) and the element Swallow on rings (hold time 3 s). Both values are normalized to body weight (n=9).

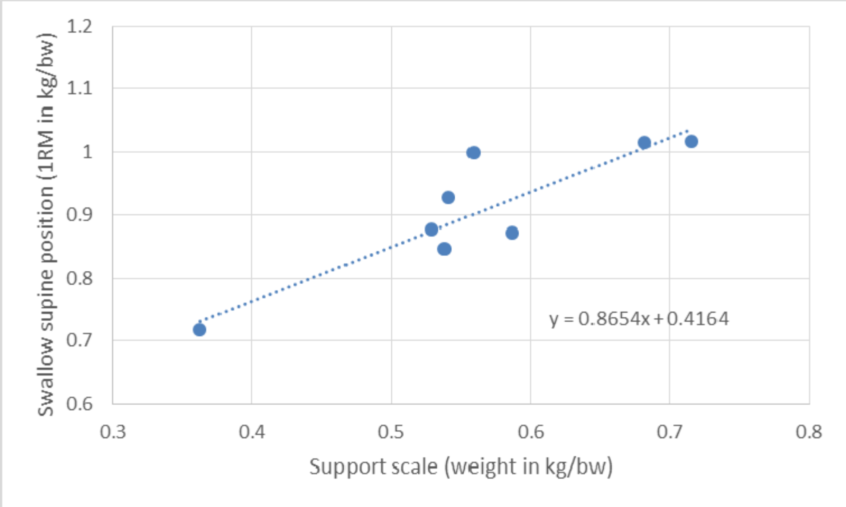

Figure 16. Correlation between maximal resistances for the preconditioning exercise Swallow supine position and the element Support Scale on rings (hold time 3 s). Both values are normalized to body weight (n=9).

The correlation between relative maximal resistance in the preconditioning exercise S_{sup} and the element S on Rings is depicted in figure 15. According to this correlation, the maximal resistance for S (holding time 3 s) can be calculated. Namely, it suggests that an athlete must have a 1RM for the exercise S_{sup} of 73.4% of body weight in order to successfully perform S on rings.

Conducting the same analysis for the element SS on Rings figure 16, the results suggest that a minimum 1RM of 67.4% of body weight (S_{sup}) is required.

Correlations between the three elements on rings (table 4) revealed strong relationships.

Body weight did not correlate with the maximal resistance for elements on Rings and their preconditioning exercises. Body size correlated with maximal resistance only for the element S (r: -0.69, p: 0.04), whereas age correlated only with the preconditioning exercise SS_{stand} (r: 0.69, p: 0.028).

DISCUSSION

Significant correlations were only observed between S and the preconditioning exercises S_{sup} (r: 0.71, p: 0.031) and BP (r: 0.71, p: 0.046); and between SS and S_{sup} (r: 0.69, p: 0.039). C had the highest correlation (but not significant) with the C_{belt} (r: 0.66, p: 0.051) and Bench press (r: 0.67, p: 0.069).

The hypothesis that the ring strength correlates well with the exercises of nearly identical body position could only partially be confirmed (S_{sup} with S and SS; C_{belt} tend to correlate with C). A possible cause for the lower correlations with the preconditioning strengthening exercise $S_{sup\ ant}$ is that athletes tended to associate pain or inflammation with this exercise in daily training.

Other than the nearly identical body position, another reason for the very high correlation between the exercises S_{sup} and the S on Rings is that the athlete's body weight stabilizes the scapula between the thoracic wall and the bench (Bernasconi et al, 2013). The low correlation between the preconditioning exercise SS_{stand} and the elements on Rings is probably due to the standing position which makes it possible for athletes to create an impulse to lift the dumbbells using their legs. This impulse however cannot be created during the exercise on Rings. The strong correlations between the bench press exercise and all three ring strength elements (though only one was significant) were surprising, since bench press is rather unspecific at first glance. However, the importance of the pectoral muscles for the holding elements on rings could help explain these relationships.

Altogether, the preconditioning strengthening exercises S_{sup}, BD and C_{belt} (and perhaps C as well) appear to be useful as preparatory exercises for the three elements S, SS and C on Rings.

The correlation calculations yielded equations which can be used to determine minimum 1RM values needed to be achieved on the preconditioning exercises in order to be able to hold the elements on Rings. These values should only be used as guidelines because other factors, such as body structure/lever ratio and coordinative skills (sense of position), may influence these values slightly. Traditionally, according to the French training practice, 75% of the athlete's body weight needs to be moved in the preconditioning exercise S_{sup} in order for the athlete to be able to hold the element S on Rings. This value is very close to the 73.4% being predicted by the equations from the correlation calculations. Gorosito (2013) found that 60% of body weight needs to be moved in a similar (starting position) isometric maximal strength test using dumbbells, in order to be able to hold the element S on Rings. These minimum values are useful objectives to be used for training practice.

The very high correlation between the elements on rings is not surprising, since the movement execution between the elements S and SS are very similar, and certain characteristics (lever relation, specialization on rings) have similar influence on all strength elements on Rings. Similarities include the starting position and general muscle activity.

From an ethical health-conscious standpoint, is fortunate that body weight does not correlate with strength elements on Rings (similar results were found in a study about S on Rings by Bango, Sillero-Quintana & Grande (2013)) and the preconditioning strengthening exercises and that body size only correlated with the element S on rings. In our subjects, age did not correlate with ring strength, which is contrary to the findings of (Bango, 2013). One reason could be the more homogenous performance level of our subjects.

From a methodological standpoint, the use of video for determining the arm-torso angle during the ring elements reduced the measurement error that can arise with subjective assessments (Dallas, 2011; Plessner & Schallies, 2005). The 1RM testing (especially bench press) is a reliable measurement for upper body strength (Seo et al, 2012; Augustsson & Svantesson, 2013; Taylor & Brandy, 2005).

This study was conducted with all 10 top-level athletes from the Swiss national team. Nonetheless, follow-up studies using a larger cohort, where all athletes are able to conduct these difficult elements on Rings, would be of interest. Additional, a training intervention study analyzing the effects of these preconditioning strengthening exercises on ring strength over a certain time span would be interesting.

CONCLUSIONS

In summary, it can be concluded that:

- The high correlations between the preconditioning strengthening exercises S_{sup} and BP with the elements S, SS and C on Rings confirm the usefulness of these training exercises.
- The equations can be used to predict a minimal value needed in the 1RM for all preconditioning exercises, which are important for the training process. For the preconditioning exercise with the highest correlation (S_{sup}) to the strength element on Rings, a minimal 1RM of 73.4% of body weight is needed in order to be able to hold the element S on Rings for the required 3 s. The corresponding value for SS on Rings is a minimal 1RM 67.4% of body weight of the S_{sup}.

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