

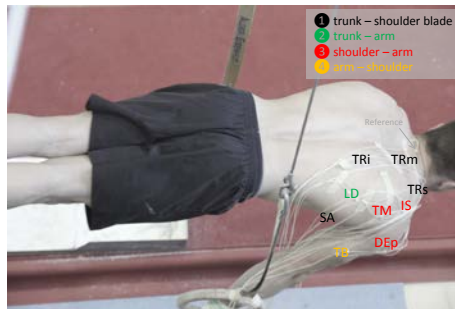
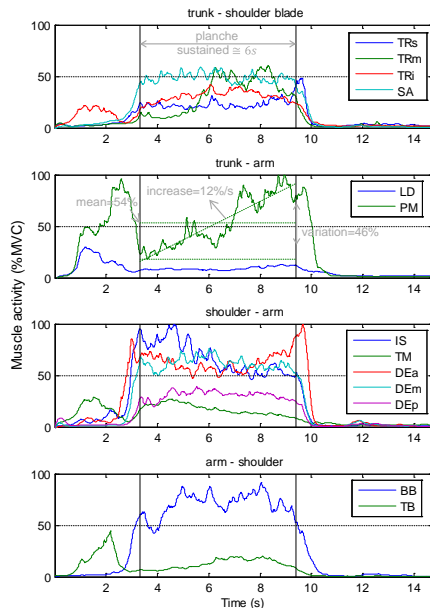
## INTRODUCTION

The planche represents an important strength and hold element on the still rings, but it's muscle activity was only investigated in a few studies. For instance differences in muscle activity was analyzed for the swallow, another strength and hold element [1]. In this previous study averaged activity was considered, thus it remains unknown how the muscle activity changes over time when sustaining the planche on the still rings.

The aim of this study was to determine the dynamic contribution of nine muscles around the shoulder, while elite gymnasts sustained the planche for as long as possible.

## METHODS

In six elite gymnasts we measured nine muscles surrounding the shoulder with surface electromyography (EMG) organized in four functional groups (Fig1): 1) Trapezius superior, mid, inferior (TRs, TRm, TRi), serratus anterior (SA), 2) latissimus dorsi (LD), pectoralis major (PM), 3) infraspinatus (IS), teres major (TM), deltoid anterior, mid, posterior (DEa, DEm, DEp), 4) biceps and triceps brachii (BB, TB). From the processed EMG envelopes [2] that were normalized to maximum voluntary contraction (%MVC) we calculated mean, variation and increase (%MVC/s) while sustaining the planche (Fig1) for as long as possible.



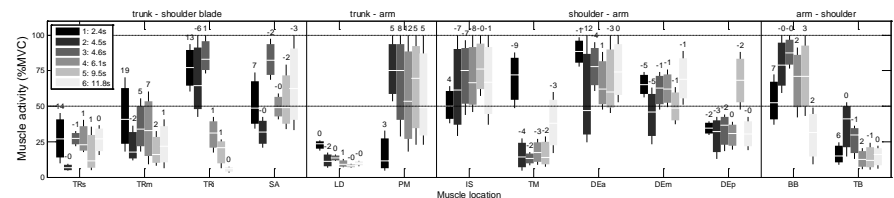
**Fig1:** Upper panel shows a gymnast sustaining the planche and the electrode location of dorsal muscles. Left panel shows EMG envelopes of a representative gymnast sustaining the planche for a duration of 6 s (vertical lines). From the EMG envelopes we calculated the mean, the variation and the increase in muscle activity.

## RESULTS

The planche was sustained for a duration of 2.4–11.8 s. As can be seen in Tab1 overall main active muscles were PM-DEm-BB-IS-DEa (56-68%). The variation in muscle activity was largest for DEa-IS-TRm-PM (11-24%). From the main active muscles the activity of DEm-IS-DEa primarily decreased over time, while for BB and PM it increased over time (see Tab1). As large spread over all subjects were found, data of individual gymnasts are additionally presented, which indicate subject-specific muscle activities (Fig2).

**Tab1:** Overall measures of muscle activity (mean, variation, increase) when sustaining the planche. Dark to light gray fields indicate important main active muscles.

	trunk - shoulder blade				trunk - arm		shoulder - arm					arm - shoulder	
	TRs	TRm	TRi	SA	LD	PM	IS	TM	DEa	DEm	DEp	BB	TB
mean (%MVC)	20±9	27±10	47±32	54±17	12±6	56±24	66±10	28±23	68±15	59±15	39±15	65±20	21±12
Var (%MVC)	6±6	15±13	9±7	10±7	2±1	24±13	15±7	10±5	14±4	8±2	7±3	11±3	7±3
Increase (%MVC/s)	3±6	5±7	2±6	0±4	0±1	7±3	-3±5	-4±5	-3±5	-2±2	-1±1	2±3	1±3



**Fig2:** Dynamic muscle activity for each individual gymnast (1-6) ranked with sustained planche duration. Boxplots represent the dynamics of muscle activity; the middle line of boxplot shows the median, the box represent the interquartile range and error bars show the range in muscle activity. Values above boxplots indicate the increase in muscle activity over time (%MVC/s).

## CONCLUSION

The main active muscles were BB-IS-DEa with highest variation for DEa-IS-PM and the activity of DEa-IS decreased while for BB-PM it increased over time. Thus DEa-IS are the main limiting muscles and BB-PM become important when sustaining the planche for as long as possible. Overall, DEa and BB are expected to importantly contribute to the trunk extension moment in the shoulder, while IS and PM as well as all other muscles, expect LD, importantly contribute to stabilize the biomechanically unstable planche. However, the large overall spread and the outcome of individual gymnasts indicated a subject-specific strategy in muscle activity when sustaining the planche for as long as possible.

## References

- [1] Bemasconi SM 2009 J Strength Cond Res, Can shoulder muscle coordination during the support scale at ring height be replicated during training exercises in gymnastics?
- [2] Staudenmann D 2007 J Biomech, Effects of EMG processing on biomechanical models of muscle joint systems: sensitivity of trunk muscle moments, spinal forces, and stability.