THE SEATED-SINGLE-ARM-ROW AS A POST-ACTIVATION POTENTIATION EXERCISE TO ENHANCE POWER OUTPUT DURING KAYAKING ON AN ERGOMETER

Marcus Lee[1], Grace Yong[2], Nguyen-Vinh Tan[3]

Singapore Sport Institute, Sport Singapore[1]
Nanyang Technological University[2]
A*Star, Institute of High Performance Computing[3]

This study investigated if the seated-single-arm-row (SSAR) could be used as a post-activation-potentiation-exercise (PAPE) during warm up to induce enhanced power output during kayaking on an ergometer. Ten well-trained kayakers (4 females, 6 males) performed three repetitions of the SSAR at 91% one-repetition maximum as the PAPE. Participants were assessed for their peak and average power output while performing 14 maximal effort strokes on a kayak ergometer; to simulate a race start; with versus without PAPE as a warm up, at three-minute intervals up to 18 minutes. Mean peak power with PAPE was found to be approximately 6% higher (1172.5 vs 1106.8 W) compared with no PAPE, $t(9)=2.61$, $p=0.03$. No differences in mean average power were found. Six out of the 10 kayakers registered higher mean peak and average power in one of their experimental trials compared with their control trial. These kayakers could be positive responders to PAPE. The SSAR performed during warm up enabled kayakers to increase their peak power output when paddling on an ergometer, but did not result in higher average power output. The utility of the SSAR as a PAPE to enhance overall power output when paddling on an ergometer, with the perspective of applying this technique to enhance performance during on-water kayaking, requires further investigation.

KEYWORDS: warm up, muscle stimulation, force output, race, sprint kayaking

INTRODUCTION: Post-activation-potentiation-exercise (PAPE) involves performing resistance exercises at near maximal loads for a brief moment that results in acute enhancement of muscular performance (Xenofondos et al., 2010). PAPE used as a warm up to improve sport performances should mirror the movement mechanics and involve the muscle groups used in the subsequent activity (Hodgson, Docherty & Robbins, 2005). PAPE used as a warm up prior to an explosive activity of a short duration such as sprinting, has been shown to improve sprint times (Okuno et al., 2013).

Post-activation-potentiation of muscles can occur via two mechanisms. The first involves the phosphorylation of myosin regulatory light chain causing actin-myosin to be more responsive to calcium that is released from the sarcoplasmic reticulum during muscle contractions (Hodgson, Docherty & Robbins, 2005). The second involves increased excitation of synapses within the spinal cord that improves the force-generating capacity of the muscles involved(Lorenz, 2011) . This performance enhancing effect occurs after a latency period that is highly individualized that ranges between two to 18 minutes post PAPE (Hodgson, Docherty & Robbins, 2005).

The 200 m kayak-sprint event is an Olympic sport that requires athletes to move the kayak over 200 m in the shortest time possible (Baker, 2012). A 200 m race is usually completed in less than 40 s (Byrnes & Kearney, 1997). The difference between winning and losing the Men's kayak single (K1) 200 m event at the 2016 Olympics was 0.165 s. As such, a fast and explosive start has been reported to be a decisive contributor to race outcomes (Szanto, 2011). The athlete who is able to generate and transfer more power into his/her strokes at the start could gain an advantage over his/her opponents.

The seated-single-arm-row (SSAR) is a resistance exercise that kayak coaches prescribe to their athletes to mimic the biomechanics of the catch and pull during kayaking and to also primarily train the upper-body muscles involved during the performance of those skills. Previous studies have indicated that performing approximately three to five repetitions at loads

above 80% of one's one repetition max (1RM) of heavy resistance exercises such as squats and Olympic lifts can improve the performance of subsequent explosive activities such as jumps or sprints (Okuno et al., 2013; Chatzopoulos et al., 2007). The SSAR, if prescribed appropriately to a kayaker, may serve as a PAPE to enhance acute power output for more powerful starts.

This study investigates whether performing the three repetitions of the SSAR at 91% 1RM (Bevan et al., 2010) prior to performing 14 all-out strokes on a kayak ergometer to simulate the start would result in higher power output. We hypothesized that peak and average power output across 14 strokes would be higher when kayakers add the SSAR as part of their warm up compared with the absence of it.

METHODS: Ten well-trained kayakers (4 females and 6 males; Age=19.4±2.9 yrs; Height=166.3±9.6 cm; Mass=62.7±9.6 kg; Training experience=4.3±0.8 yrs) participated in this study. All participants were injury free at the point of testing and have competed in national and regional kayaking competitions. The kayakers were all sprinters who raced across both the 200m and 500m distances. All procedures were approved by the institutional review board of the Singapore Sport Institute. Participants were required to perform the SSAR (Figure 1) bilaterally to ascertain their 1RM after a 15 minute, self-selected warm up. All participants were familiar with the SSAR as they often performed this exercise as part of their strength and conditioning program. Participants were given a maximum of four attempts to achieve their 1RM. Four minutes of rest was provided between each attempt to minimize fatigue and so as to accurately ascertain each participant's 1RM. Every subsequent attempt after the penultimate attempt was accompanied by an increase in weight and a decrease in the number of repetitions. The 1RM was ascertained when a participant achieved 90 degrees elbow flexion on one trial but is unable to do so on the second trial. Participants were filmed using a digital video camera when performing the trials and elbow angles were calculated using the Kinovea software. Participants were required to rest for 20 minutes after the ascertainment of their 1RM performing the SSAR and prior to being tested on the kayak ergometer (Kayak Pro, Speedstroke Gym-Kayak, USA). The kayak ergometer's fly wheel was set at resistance level 10 for the males and six for the females as advised by their coach. The control condition required participants to perform 15 minutes of self-selected warm up before performing 14 maximal effort strokes from a stationary start on the ergometer. The experimental condition required participants to perform 15 minutes of self-selected warm up followed by performing three repetitions at 91% 1RM of the SSAR bilaterally, before performing 14 maximal effort strokes from a stationary start on the ergometer at three-minute intervals up to 18 minutes post PAPE. Fourteen strokes were chosen to represent the start as it is the average number of strokes required for participants to reach 30 m during on-water kayaking as ascertained from historical video data. Participants were assigned in a counterbalanced manner to either start with the control or experimental condition, followed by the contrasting condition after a 20 minute rest period. A video camera recorded the power output of every stroke displayed on the console that was later input into a spreadsheet. The stroke that generated the highest peak power and average power across 14 strokes in the control condition as well as at every three-minute interval during the experimental condition were measured. SPSS (Version 16.0, SPSS Inc., Chicago, IL) was used to assess the normality of all data before the performance of two-tailed paired t-tests ($p<0.05$) to compare peak and average power achieved during the specific experimental versus control trial.

Figure 1. Participant performing the SSAR to ascertain 1RM and thereafter, 91% of 1RM.

RESULTS: Table 1 documents the data of each participant. Each participant had their unique latencies post-PAPE to generate their highest peak power within 14 strokes. Mean peak power of participants was approximately 6% higher in the experimental versus control trial (1172.5 vs 1106.8 W), t(9)=2.61, p=0.03. No differences in mean average power were found between the individual experimental trials at each time interval versus the control trial (549.9 vs 516.9 W), t(9)=1.36, p=0.21.

Table 1. Bio and performance data of every participant

Participant	Sex	SSAR 91% 1RM_Left (kg)	SSAR 91% 1RM_Right (kg)	Peak Power_ Experimental (W)	Peak Power_ Control (W)	Average Power_ Experimental (W)	Average Power_ Control (W)	Latency to Peak Power Post PAPE (mins)
1	M	126	126	1173	1054	535.3	505.8	6
2	M	118	125	1796	1687	778.2	724.7	12
3	F	75	75	794	577	382.2	367.7	12
4	F	78	78	997	1025	490	499.7	9
5	M	123	123	1771	1753	686.5	700	15
6	M	105	105	1628	1533	712.7	710.3	18
7	F	59	59	557	479	259.6	251.5	6
8	M	91	77	1160	1184	709.8	467.6	12
9	F	76	76	776	678	396.7	371.3	6
10	M	109	109	1073	1098	547.9	569.9	9

DISCUSSION: This study investigated if the SSAR could be used as a PAPE during warm up to enhance power output during a simulated start for sprint kayaking on an ergometer. Our hypothesis was partially supported. Mean peak power with PAPE performed during the warm up was found to be approximately 6% higher compared with no PAPE, but there were no differences in mean average power.

This study's findings partially support previous studies whereby PAPE in the form of sport-specific resistance exercises such as sled pulls and running with a parachute resulted in enhanced sprint performances (Winwood et al., 2016). Net muscular force generated after heavy resistance warm up exercises such as PAPE is a balance between fatigue and potentiation (Docherty & Hodgson, 2007). Performing three repetitions of the SSAR at 91% 1 RM bilaterally took less than 20 seconds to complete. This could have evoked muscle potentiation instead of fatigue, resulting in the higher mean peak power output observed in the associated experimental compared with control trial.

The usefulness of higher mean peak power output is however put into question from an overall performance perspective as average power across 14 strokes during the simulated start was not statistically higher in the experimental versus control conditions. Extending the possibility of warming up using the SSAR as PAPE, it could be argued that while on average kayakers might be able to start more powerfully, this advantage may be short-lived as it cannot be sustained across the first 14 strokes. There are responders and non-responders to the effect of PAPE. Positive (Wilson et al., 2013), negative (Chiu et al., 2003) and no effects (Gourgoulis et al., 2003) on muscular performances have been reported in the literature. Closer inspection of the performance data of each participant suggests that some of the participants demonstrated increased peak and average power output in the experimental condition. Perhaps, using the SSAR as a PAPE to enhance power output while kayaking on an ergometer could be more suitable for them.

This study was performed with the intention of applying the learnings to create a warm-up protocol that is suitable for on-water sprint kayaking over 200m, and hopefully using appropriate PAPE, enable sprint kayakers to increase their power output to improve their timings over this distance. The statistically significant increase in mean peak power output for the group and selective increase in mean average power output requires further investigation to allow practitioners to tap into this phenomenon to improve on-water sprint kayaking performance. A matching of exertion between performing the land-based SSAR and a water-based PAPE would also be required so that the warm up protocol is more ecological valid for race preparation.

CONCLUSION: This study's findings suggest that the SSAR could be used as a PAPE during warm up to acutely increase peak power output but not average power output across 14 maximal effort strokes performed on a kayak ergometer. While the applied value of these findings requires further uncovering before generalizations can be made, 6 out of the 10 kayakers registered higher mean peak and average power in one of their experimental trials compared with their control trial. These kayakers could be positive responders to PAPE (Wilson et al., 2013). In sprint kayaking, whereby a gold and silver medal in the K1 200 metres Men's Final A at the 2021 Tokyo Olympics was differentiated by a time of 0.045 s, any potential advantage is valuable. Future research should continue to explore developing an on-water equivalent PAPE to be included as part of a kayaker's warm up routine that serves to enhance power output, and improve start and overall race times.

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