Within-session and between-session reliability of the seven-stroke maximal effort test in national level senior rowers.
Journal of Australian Strength & Conditioning. 27(04):22-28, 2019 © ASCA.

Original Scientific Research Study

WITHIN-SESSION AND BETWEEN-SESSION RELIABILITY OF THE SEVEN-STROKE MAXIMAL EFFORT TEST IN NATIONAL LEVEL SENIOR ROWERS.

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BLUF

The seven-stroke maximal effort test on a rowing ergometer using an unrestricted stroke rate is a reliable test of maximal force and power output in rowers.

ABSTRACT

The purpose of this study was to measure the within- and between-session reliability of the seven-stroke maximal effort (7SM) test on a rowing ergometer (Concept2® system, model C, Vermont, USA) using an unrestricted stroke rate. Ten national level senior male rowers (age: 26 ± 4 years; height: 186 ± 5.2 cm; body mass: 84.3 ± 6.8 kg; rowing experience: 7 ± 3 years) participated in this study. During session one, subjects performed three 7SM tests with a 4 minutes passive rest interval between tests. During session two and three, subjects performed one 7SM test. Within-session (comparison of three 7SM tests from session one) and between-session (comparison of the initial 7SM test from session one, two and three) reliability was assessed using one-way repeated-measures ANOVA, intraclass correlation coefficients (ICC), coefficient of variation (CV%) and standard error of measurement (SEM). The smallest detectable difference (SDD) was calculated for practical applications. Within-session reliability was good to high for all force, power and stroke rate variables (ICC = 0.88 – 0.99, CV = 1.0 – 2.4%, $p > 0.05$ for all). Between-session reliability was high for all force and power variables (ICC = 0.96 – 0.97, CV = 1.3 – 2.2%, $p > 0.05$ for all) but questionable for stroke rate variables (ICC = 0.72 – 0.77, CV = 2.5 – 2.7%, $p < 0.05$ for all). The 7SM test using an unrestricted stroke rate is a reliable, practical and readily accessible test of maximal force and power output in rowers. The SEM and SDD values provided can help strength and conditioning (S&C) coaches to evaluate true changes in 7SM test performance and eliminate measurement error as a cause of change.

Key Words – Rowing performance, power, force, intrasession, intersession.

INTRODUCTION

The Olympic distance rowing race is performed over 2000 m lasting between 5:18.68 and 7:24.46 minutes, based on current world best times. During a 2000 m race, the aerobic energy system has been shown to account for between 70 to 86% of total energy production with the remaining energy produced through the anaerobic energy system (20, 24, 31). Training programmes generally comprise of a variety of modalities including on-water training, rowing ergometer training, strength training, flexibility sessions and cross training (running, cycling, etc.) (36). Strength training is an area that may improve performance by increasing propulsive power during the rowing stroke, thus achieving faster boat speeds (16). This may be of particular importance during the start of a rowing race where rowers need to accelerate the boat quickly out of the starting blocks in order to get an early lead, which can be an important tactical advantage as rowers are positioned with their back to the finish line. During the initial 10 seconds of a rowing race, peak rowing stroke force has been shown to reach 1000 to 1500 Newton (N) with the force typically levelling off at 500 to 700 N during the middle part of the race (34). Therefore, high levels of strength (force) and power output appear to be important for rowers, which is further supported by the moderate to strong correlations between muscular strength/power tests and 2000 m rowing performance ($r = 0.58 – 0.95$) (13, 18, 26).

Physical testing of athletic qualities such as strength, power, aerobic capacity, etc. is an important component in the prescription and evaluation of effective training programmes across all sports (21). The physical testing data can be used to compare individuals against normative values, specific to their athletic population, and can help to guide practitioners on the individual's strengths and weaknesses from a physical standpoint (21). A variety of physical tests have been used to assess strength and power characteristics of rowers. Early studies utilised isometric tests (28, 33) and isokinetic tests (14, 32) with more recent studies utilising dynamometers (17, 18) and traditional barbell strength tests (18, 22). However isometric and isokinetic tests can, in many cases, lack specificity while dynamometers may not be readily accessible to the majority of S&C coaches. A number of studies have used short duration maximal effort rowing ergometer tests of between 8 to 14 seconds in duration as outcome measures (5, 7, 13, 23, 26, 27). A test of this nature may be a more sports-specific measure of the anaerobic-alactic demands of a rowing race, such as the initial sprint from the starting blocks, and could also be used in combination with dynamometers or traditional barbell strength tests in order to provide more in-depth force and power analysis for S&C coaches working with rowers. In addition, short duration rowing ergometer tests, such as the seven stroke maximal effort test (7SM) have been found to have a strong correlation to elite rowing ergometer performance over 2000 m (r = 0.93 – 0.95) (13, 26). However, the testing format differs between studies and consequently the reliability of these tests are varied. Reliability of a test refers to the consistency or reproducibility of performance outcomes when the test is performed repeatedly (12). Establishing the reliability of a test is crucial in order to accurately track performance changes for an athlete both within a single training session (i.e. within-session reliability) and across multiple training sessions (i.e. between-session reliability) (12).

Doma et al. (5) assessed the between-session reliability of a 10 second maximal effort rowing ergometer test and reported high ICC values for mean and peak power output (ICC = 0.98 for both), mean stroke rate (ICC = 0.88) but a low ICC value for peak stroke rate (ICC = 0.35). However, stroke rate (i.e. the number of rowing strokes per minute) was not controlled during this study which may have influenced the low ICC value of peak stroke rate (ICC = 0.35). Metikos et al. (23) assessed the between-session reliability of a 12 stroke maximal effort ergometer test and reported high reliability for peak power (ICC = 0.87 – 0.98; CV = 2.6 – 6.5%) however stroke rate was not controlled for, similar to Doma et al. (5). Rowers typically reduce their stroke length (i.e. the distance the rowing oar/ergometer handle travels for each rowing stroke) during short duration maximal effort ergometer tests, thus increasing stroke rate. Therefore, controlling for potential variances in stroke rate during testing may be vital to increase reliability of the test.

In an effort to better control for the effects of potential variances in stroke rate during testing, a number of studies utilised a 7SM at a restricted stroke rate of 30 strokes per minute (strokes/min) (7, 13, 26, 27). However, maintaining a restricted stroke rate over a short duration maximal effort test is technically difficult and may not effectively replicate the demands of a rowing race where stroke rates of > 45 strokes/min are common during the first 10 seconds. The reliability of the 7SM test using an unrestricted stroke rate needs to be determined as the test may have numerous acute and longitudinal applications for monitoring rowers force and power levels. The 7SM test is shorter in duration when compared to tests such as the 10 second test (5), the 12 stroke test (23), 30 second test (25) and the 100 m test (35). Therefore, the 7SM test could potentially be implemented as a monitoring tool on a regular basis by S&C coaches as the physiological demands (e.g. blood lactate accumulation) are lower than other tests, thus the fatigue associated with regular testing should be lower. The aim of this study is to investigate the within-session and between-session reliability of the 7SM test using an unrestricted stroke rate in national level senior male rowers.

METHODS

Approach to the Problem
The study was a repeated measures design. Three separate testing sessions were conducted in order to investigate the within-session and between-session reliability of the 7SM test. Each testing session was separated by a one-week period.

Subjects
Ten male rowers (age: 26 ± 4 years; height: 186 ± 5.2 cm; body mass: 84.3 ± 6.8 kg; rowing experience: 7 ± 3 years; 2000 m ergometer time: 6:27.8 ± 11 minutes: seconds) participated in this study. The rowers were recruited from a local rowing club; regularly competed at senior national level, consistently trained 7 – 9 sessions per week and 4 subjects were national rowing champions during the previous season. All of the rowers were healthy, free from injury and familiar with the 7SM test at the beginning of the study.

Procedures
Approval to conduct this study was provided by the university ethics committee. Prior to participating, all subjects were provided with an information sheet and provided written informed consent. A rowing ergometer (Concept2® system, model C, Morrisville, Vermont, USA) was custom fitted with a load cell (VPG Transducers, model 615) for measuring force variables during testing procedures. The load cell was attached to the handle of the rowing ergometer and the signal was sampled at 1000 Hz. The load cell was connected by a cable to a data acquisition system (PowerLab, AD Instruments, UK) that exported the data to a PC where it was processed using data analysis software (LabChart 8, AD Instruments, UK). Figure 1 displays the load cell set up during 7SM testing. The load cell was calibrated by the university technician to 1491 N using known static weights. Power and stroke rate variables were measured using the digital display on the rowing ergometer. The rowing ergometer was set to a drag factor of 140 which is frequently used during testing for senior male rowers (7, 29).

Figure 1 – Rowing ergometer custom fitted with a load cell for the 7SM test.

Prior to each testing session, subjects were advised to replicate their nutritional intake, to avoid any strenuous exercise (e.g. high-intensity rowing/ergometer training, S&C sessions, etc.) 48 hours prior to testing and to wear the same footwear during all testing sessions. All testing was performed at the same time of day (± 2 hours) to minimise any diurnal variation. A standardised warm up was performed, which involved: 3 minutes of low intensity rowing (heart rate < 150 beats per minute), 3 minutes of dynamic stretching and 3 minutes of low intensity rowing with one, two, three and four maximal practice strokes from a standing start. The first data collection session assessed within-session reliability (i.e. trial one to three reliability) of the 7SM test and involved each subject performing three 7SM tests with a 4 minute passive rest interval between each test. A 4-minute passive rest interval was used because pilot testing of the 7SM test with 4 subjects revealed that > 3 minutes rest was needed to ensure the ergometer flywheel was static prior to each test. In addition, the 7SM test is performed as a maximal effort lasting between 8 – 9 seconds in duration and is therefore highly dependent on anaerobic-alactic metabolism which may require a longer rest interval (i.e. 4 minutes) between tests to ensure full recovery. All subjects received standardized instructions – "to perform seven maximal effort rowing strokes at full length from a stationary start" and a visual marker of full rowing stroke length was provided. The visual marker (two upright flexible plastic rods attached to the ergometer frame) was set to each subjects' full rowing stroke length at the catch phase of the rowing stroke. Each subjects' catch position was verified by an experienced rowing coach. In addition to the visual marker, a video camcorder (JVC Everio, Model GZ-MG130EK, USA) was used to record each 7SM test to ensure each stroke was performed at full length, if not, the 7SM test was excluded from data analysis. To minimise information bias, the digital display on the rowing ergometer was hidden from the subjects view during all testing sessions to ensure subjects were unaware of their power and stroke rate data. The second and third data collection sessions involved the same procedures however only one 7SM test was performed by each subject. In order to assess between-session reliability (i.e. session one to three reliability), the initial 7SM test from the first data collection session was compared with each respective 7SM test from the second and third data collection sessions.

Statistical Analysis

Statistical analyses were performed using SPSS software version 21 (SPSS, Chicago, I11, USA). Normality of the data was confirmed both visually, using boxplots, and using the Shapiro-Wilk test ($p > 0.05$ for all variables). In line with the recommendations of Atkinson and Nevill (1) the following three components of reliability were assessed: (a) systematic bias (i.e. effects from learning, fatigue, motivation), (b) relative reliability (i.e. the degree to which subjects maintain their rank in the sample) and (c) absolute reliability (i.e. the degree of variability in the repeated measures of each subject). Systematic bias between trials one to three (within-session) and session one to three (between-session) was assessed using separate one-way repeated-measures ANOVA with Bonferroni post hoc analysis. Significance level was set at $p < 0.05$. Relative reliability was assessed using a two-way mixed model of intraclass correlation coefficient (ICC) with 95% confidence intervals (CI) (38). Absolute reliability was assessed using the coefficient of variation (CV) with 95% CI (10) and the standard error of measurement (SEM) (38). The CV was calculated based on the mean square error term of logarithmically transformed data (11) and the SEM was calculated using the formula: SEM = SD (pooled) × $\sqrt{1 - ICC}$ (38). In addition, the smallest detectable difference (SDD) was calculated in order to be confident that a significant change in an individual's performance had occurred: SDD = 1.96 × $\sqrt{2}$ × SEM (15).

RESULTS

Descriptive statistics of within-session and between-session scores can be found in Table 1. Two 7SM tests were excluded from the second testing session as they did not meet the testing criteria of full rowing stroke length. No significant differences were found in the within-session scores ($p > 0.05$ for all variables), suggesting that systematic bias (i.e. learning affects, motivation, fatigue, etc.) was not present, see Table 2. However, significant differences were found in the between-session scores for mean stroke rate ($p = 0.01$) and peak stroke rate ($p = 0.03$), suggesting that systematic bias was present, see Table 3. Despite this, no further significant differences were found in the between-session reliability scores for the 7SM variables ($p > 0.05$ for all variables). Within-session reliability was acceptable for all force variables (ICC = 0.94 – 0.99, CV = 1.0 – 2.4%, SEM = 10 – 26.2 Newton), power variables (ICC = 0.99, CV = 1.1 – 1.2%, SEM = 8.2 – 8.5 Watts) and stroke rate variables (ICC = 0.88 – 0.91, CV = 1.6 – 2.1%, SEM = 1 stroke per minute), see Table 2. Between-session reliability was acceptable for all force variables (ICC = 0.97, CV = 1.3%, SEM = 18.6 –19.4 Newton), power variables (ICC = 0.96, CV = 2.1 – 2.2%, SEM = 15.4 – 15.5 Watts) but appeared lower for stroke rate variables (ICC = 0.72 – 0.77, CV = 2.5 – 2.7%, SEM = 1 – 2 strokes per minute), see Table 3. In addition, the SDD was provided in Table 2 and 3 for practical applications.

Table 1 - Descriptive statistics (mean ± SD) of 7SM test variables for within-session and between-session scores (*n* = 10).

Variables	Within-Session			Between-Session		
	Trial 1	Trial 2	Trial 3	Session 1	Session 2	Session 3
Mean stroke rate (strokes/min)	48 ± 3	47 ± 3	47 ± 2	48 ± 3	48 ± 3	49 ± 3
Peak stroke rate (strokes/min)	49 ± 3	49 ± 3	49 ± 2	49 ± 3	50 ± 3	51 ± 4
Mean force (N)	1176.1 ± 100	1180.6 ± 100	1177.8 ± 100.5	1188.2 ± 110.9	1190.6 ± 104.4	1179.3 ± 107.1
Peak force (N)	1276.1 ± 102.1	1262.9 ± 108.6	1257.5 ± 109.9	1281.1 ± 120.1	1272.6 ± 108.2	1271.6 ± 107.8
Mean power (W)	711.4 ± 77.3	711.8 ± 83.2	702.9 ± 84.8	714.2 ± 80	722 ± 74.3	728.5 ± 78.65
Peak power (W)	751.5 ± 80.1	754.8 ± 84.4	747.3 ± 89	753.3 ± 81.9	765.3 ± 71.3	767.5 ± 78.1

Key: strokes/min = rowing strokes per minute; W = Watt; N = Newton.

Table 2 - Within-session reliability of 7SM test variables (*n* = 10).

Variables	ICC (95% CI)	CV (%) (95% CI)	SEM*	SDD*	*p* value
Mean stroke rate (strokes/min)	0.91 (0.77 - 0.98)	1.6 (1.1 - 2.5)	1	2	0.14
Peak stroke rate (strokes/min)	0.88 (0.70 - 0.97)	2.1 (1.5 - 3.3)	1	3	0.77
Mean force (N)	0.99 (0.96 – 1.0)	1.0 (0.7 - 1.5)	10.0	27.7	0.63
Peak force (N)	0.94 (0.83 - 0.98)	2.4 (1.7 - 3.8)	26.2	72.6	0.30
Mean power (W)	0.99 (0.96 - 1.0)	1.2 (0.9 - 1.9)	8.2	22.7	0.07
Peak power (W)	0.99 (0.97 - 1.0)	1.1 (0.8 - 1.8)	8.5	23.4	0.20

Key: strokes/min = rowing strokes per minute; W = Watt; N = Newton; *measurement unit is specific to each variable.

Table 3 - Between-session reliability of 7SM test variables (*n* = 10).

Variables	ICC (95% CI)	CV (%) (95% CI)	SEM*	SDD*	*p* value
Mean stroke rate (strokes/min)	0.77 (0.45 - 0.93)	2.5 (1.8 - 3.9)	1	4	0.01
Peak stroke rate (strokes/min)	0.72 (0.39 - 0.91)	2.7 (1.9 - 4.2)	2	5	0.03
Mean force (N)	0.97 (0.92 - 0.99)	1.3 (1.0 - 2.1)	18.6	51.7	0.36
Peak force (N)	0.97 (0.90 - 0.99)	1.3 (1.0 - 2.1)	19.4	53.9	0.50
Mean power (W)	0.96 (0.89 - 0.99)	2.1 (1.5 - 3.3)	15.5	37.3	0.11
Peak power (W)	0.96 (0.88 - 0.99)	2.2 (1.6 - 3.4)	15.4	42.8	0.09

Key: strokes/min = rowing strokes per minute; W = Watt; N = Newton; *measurement unit is specific to each variable.

DISCUSSION

The aim of this study was to investigate the within- and between-session reliability of the 7SM test using an unrestricted stroke rate in national level senior rowers. The main findings demonstrated that the 7SM test has acceptable reliability for all force, power and stroke rate variables for within-session scores. Similarly, all force and power variables for between-session scores were reliable however systematic bias and low ICC values were found for mean stroke rate and peak stroke rate. To our knowledge, this is the first study to provide a comprehensive reliability assessment (i.e. systematic bias, relative and absolute reliability) of the 7SM test using an unrestricted stroke rate. This testing format more accurately replicates the true physical demands of a rowing race in comparison to the previously utilised 7SM test at a restricted stroke rate of 30 strokes/min (7, 13, 27). In addition, SEM and SDD values were provided to assist S&C coaches to evaluate true changes in performance and eliminate measurement error as a cause of change.

Significant differences were found in mean and peak stroke rate for the between-session scores suggesting that systematic bias was present. Systematic bias refers to a general trend for measurements to be different between repeated tests and is suggested to occur due to influencing factors such as learning affects, motivation or fatigue (1). In our study, the subjects were senior national level rowers with a large amount of rowing experience (7 ± 3 years) and should therefore be highly familiar with rowing ergometer tests. In addition, the 7SM testing conditions were strictly controlled and all participants followed the same rowing training programme across the 4 week testing period, to ensure fatigue levels were similar. However, ICC values for mean and peak stroke rate ranged from 0.72 to 0.77 which further suggests that stroke rate may need to be more strictly controlled during future studies.

Despite this, accurate analysis of ICC values can be challenging as numerous methods of calculating and interpreting ICC values exist in the current literature (1, 38). For example, Fleiss (6) suggests ICC values of > 0.75 indicates "high" reliability, 0.40 to 0.75 indicates "good" reliability and < 0.40 indicates "poor" reliability. This is in contrast to Vincent (37) who suggests ICC values of > 0.90 indicates "high" reliability, while 0.80 to 0.90 indicates "good" reliability and 0.70 to 0.80 indicates "questionable" reliability. The results of the present study reported ICC values that ranged from 0.94 to 0.99 for all force and power variables, thus indicating high reliability across both within- and between-session scores. A similar study by Doma et al. (5) assessed the between-session reliability of a 10 second maximal effort rowing ergometer test in university rowers and reported an ICC value of 0.98 for both mean and peak power output, 0.88 for mean stroke rate and 0.35 for peak stroke rate. However Doma et al. (5) used an unrestricted stroke rate during the testing protocol and did not attempt to standardize stroke length during testing using either a motion analysis system or flexible plastic rods. This may have contributed to the low ICC of 0.35 for peak stroke rate. In addition, no force variables were assessed for reliability.

Similar to the ICC, there are various methods of calculating and interpreting a CV value with some studies suggesting CV values of < 10% (3, 8) indicates low variability in the repeated measures of each subject while others suggest a CV of < 5% (17, 30). The results of our study reported CV values of 1.0 to 2.4% for within-session scores and 1.3 to 2.7% for between-session scores. These values are well below the more conservative CV value of < 5% which indicates there was low variability in the repeated measures of each subject for both within- and between-session scores. A similar study by Metikos et al. (23) assessed the between-session reliability of a 12 stroke peak power rowing ergometer test using subjects with varying levels of physical activity. Peak power was reported as having a CV value ranging from 2.6 to 6.5% however stroke rate was again uncontrolled, the subjects were not competitive rowers and the reliability analysis was limited to one outcome measure (i.e. peak power).

To our knowledge, this is the first study to provide SEM and SDD values for a short duration maximal effort ergometer test. The SEM values provided show the range in which an individual's true performance score is likely to be (38), whereas the SDD allows S&C coaches to interpret whether a change in an individual's performance is significant (15). The SEM and SDD values provided will allow S&C coaches to evaluate true changes in performance and eliminate measurement error as a cause of change. This will help S&C coaches to make more informed decisions about changes in an individual's 7SM test variables both within- and between-sessions. If the same 7SM test protocols are followed, then the SEM and SDD can be utilised by other senior male rowers of a similar performance standard (i.e. 2000 m ergometer time of approx. 6:28 minutes: seconds) in order to assess true changes in performance both within- and between-sessions for this cohort. This would be valuable to S&C coaches for acute applications such as post activation potentiation (PAP) interventions, which are defined as the use of maximal or near maximal intensity conditioning activities prior to an athletic performance, with the aim of acutely enhancing subsequent performance given sufficient recovery (e.g. performing a three repetition heavy deadlift, followed by a four minutes rest and then performing a 7SM test) (9). In addition to this the 7SM test is valuable to S&C coaches for longitudinal applications such as monitoring rowers' force and power levels.

The current study has some limitations. Firstly, the testing sample consisted of senior male rowers therefore future studies should try to establish normative values and reliability in other rowing populations such as senior female rowers, junior male and female rowers. Secondly, the power data during our study was obtained from the Concept2® digital display however the power equation used by the Concept2®, for model C and D, has been found to consistently underestimate power by approximately 25 Watts (2). The Boyas et al. (2) study compared the power values obtained from the Concept2® power equation (i.e. the values provided on the digital display) to power values obtained using a position sensor and load cell, in order to calculate the equation: power = force × velocity. The Concept2® model C and D calculates power using a different equation that involves measuring the angular velocity of the ergometer flywheel and estimating power output based on the acceleration and deceleration of the flywheel (2). Therefore, future studies should aim to include a position sensor on the rowing ergometer handle to establish the reliability of power variables using the force by velocity equation.

Thirdly, the methodology used to control for stroke rate was practical and could be easily implemented by S&C coaches, however more in-depth methods could have potentially increased the between-session reliability of stroke rate variables. Rowers typically reduce their rowing stroke length (i.e. the distance the rowing oar/ergometer handle travels for each rowing stroke) during short duration maximal effort ergometer tests, thus artificially increasing stroke rate. Peak stroke rates in competition generally never exceed 55 strokes/min during the initial sprint start or finish of a race, therefore the 7SM should replicate similar peak stroke rates. Previous studies have assessed rowing stroke length using various motion analysis systems (4, 19) that measure the distance the rowing ergometer handle travels during each stroke. This could potentially be a more in-depth method of assessing stroke length, and thus stroke rate, reliability during the 7SM test. However, it is interesting to note that despite the significant differences and low ICC values for between-session stroke rate variables, all force and power variables remained reliable (ICC = 0.96 – 0.97, CV = 1.3 – 2.2%). Therefore, the significant differences found in the stroke rate variables between-sessions did not influence between-session force and power variables in this study.

PRACTICAL APPLICATIONS

The main findings of this study indicate that the 7SM test using an unrestricted stroke rate has high within-session reliability for all force, power and stroke rate variables in national level senior rowers. In addition, the 7SM test has high between-session reliability for all force and power variables. Strength and conditioning coaches can therefore be confident that the 7SM test is a reliable test of maximal force and power output in rowers.

The longitudinal applications of the 7SM test for monitoring force and power output may be of particular interest to S&C coaches as the short testing duration of between 8 to 9 seconds means that the physiological demands (e.g. blood lactate production) will be minimal in comparison to tests of 15 – 20 seconds duration (e.g. 100 m test). Therefore, the 7SM test can be easily implemented as an assessment tool on a weekly basis without inducing excessive fatigue levels. The 7SM test could be used to assess improvements in force/power output as a result of strength/power training programmes or to potentially monitor neural fatigue, similar to jump monitoring protocols in land-based sports. The SEM and SDD values provided help S&C coaches to evaluate true changes in performance and eliminate measurement error as a cause of change.

The normative values for force and power output provided in this study may also be of interest to S&C coaches. This cohort of senior male rowers were found to produce a peak power output of 762.0 ± 74.8 W, mean power of 721.6 ± 75.2 W, peak force of 1275.1 ± 108.4 N and mean force of 1186.0 ± 103.9 N. The rowers were competing at national level and 4 were national champions during the previous season. Currently, there is no normative data available on the 7SM test using an unrestricted stroke rate in elite rowers. However, it could be expected that the normative values for elite rowers would be well in excess of the values in the present study. Strength and conditioning programmes should aim to monitor a rower's force and power output using practical assessments such as the 7SM test in order to optimise rowing performance.

Funding

This study was part-funded by PESS seed funding.

Acknowledgements

The authors would like to thank Stephen Clothier for his technical assistance during this study. In addition, the authors would like to thank Dr Greg Wilson for his valuable feedback on this study.

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