

KINEMATICS AND KINETICS OF THE SEATED ROW AND IMPLICATIONS FOR CONDITIONING

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ABSTRACT. Cronin, J.B., J.V. Jones, and J.T. Hagstrom. Kinematics and kinetics of the seated row and implications for conditioning. *J. Strength Cond. Res.* 21(4):1265–1270. 2007.—Optimizing transference of gym-based strength and power gains to sporting performance necessitates a physiological and biomechanical understanding of the weight-training exercise as well as the sporting activity. With this in mind, this paper describes the kinematics and kinetics associated with a seated row. The maximal strength and concentric power-load spectrum (30–100% 1 repetition maximum [1RM]) for the cable seated row was assessed using Olympic rowers ($n = 8$). In terms of temporal characteristics, peak force across all loads occurred within the first 25% of movement time. Peak power across loads occurred within 35–45% of movement time. With regard to position, peak force occurred within 8.3% and peak power within 27–35% of the start of the concentric phase. To estimate the load that maximized mechanical power output, a quadratic was fitted to each subject's power output vs. 1RM. In terms of mean power, an estimated load of 81.4% ($\pm 9.7\%$) 1RM was found to maximize power output. A 10 and 20% change in load each side of this maximum resulted in a 1.8 and 7.3% decrease in power output, respectively. The predilection of research to train all subjects at 1 load is fundamentally flawed due to interindividual maximum power differences (range in this study = 69–100% 1RM). Also, the importance of this measure would seem questionable, given that loads either side of the load that maximizes power output do not change power output substantially.

KEY WORDS. assessment, power, strength

INTRODUCTION

Prequisite to specificity and hence optimal transference of strength and power gains to functional performance is the biomechanical and physiological understanding of both the weight training exercise and the sporting activity of interest. In terms of understanding the biomechanics associated with various weight-training exercises, a great deal of literature has investigated the kinematics and kinetics associated with the bench press (2, 4, 11, 19, 22–26), squat (5, 14, 19, 20, 26–28), and Olympic lifts (6–8, 15, 16).

Obvious from the previously cited research is the preoccupation of researchers with extension-type tasks (e.g., bench press, squat) and the very little attention given to other movement patterns. The loads that maximize power output, for example, are probably muscle specific, movement specific, or both. For example, Edgerton and colleagues (13), discussing the effects of muscle architecture, depicted maximum power output occurring at a range of isometric forces depending on whether the knee extensors (45%), knee flexors (59%), plantarflexors (35%), and dorsiflexors (53%) were studied. It would seem that greater power outputs are associated with flexor-type move-

ments. Whether this is true for in vivo, dynamic, multiarticular movements is not known.

Another limitation of the literature in this area is the preoccupation of researchers in determining the load that maximizes power output, with very little attention given to other kinetic measures and the associated kinematics. This is problematic in that a load that maximizes mechanical power output, force, or other kinetic variables of interest may not be the optimal load that maximizes output in a period important to sporting performance, such as foot contact times in sprinting (approximately 100 ms). Also, identifying the load that maximizes mechanical power output would seem of little importance, if the loads each of the maximum do not differ substantially. Research in this area for the most part has not investigated this contention, and certainly no research has determined the magnitude of this difference for flexor-type activity.

Finally, there is some evidence suggesting that subjects with greater strength training and/or athletic experience produce different kinetics, such as the relative loads that maximize power output, than their less experienced counterparts (3, 27). Indeed, if improvement of athletic performance were of primary interest, the use of athletic subjects with a resistance training background would appear of greater value than using novice or recreationally trained athletes. However, there is a preoccupation in research to use samples of convenience (e.g., university students) and extrapolate findings to other populations, a practice that is problematic at best.

Given this information, it would seem practical to study the kinematics and kinetics associated with flexor exercises that are typically used for the conditioning of athletes. One such exercise is the seated row. However, very little is known about the force-time characteristics, the load or loads that maximize mechanical power output, and the effects of varying training intensity for this exercise. The purpose of this study therefore was to describe the kinematics and kinetics associated with the seated row using elite athletes. The load that maximized mechanical power output and the differences in power output each side of these maxima were of additional interest. These findings should assist in improving training prescription.

METHODS

Experimental Approach to the Problem

This study was designed to determine the biomechanical characteristics of the seated row. For this purpose the weight stack of a cable row machine was instrumented and used to determine the kinematics and kinetics across a spectrum of loads (30–100% 1 repetition maximum [1RM]). The sample was small ($n = 8$) because elite row-

TABLE 1. Subject (mean $\pm$ SD) characteristics.

Age (y)	25.2 (3.8)
Height (m)	1.93 (0.04)
Weight (kg)	92.4 (3.8)
Rowing experience (y)	11.5 (3.8)
Weight lifting experience (y)	9.0 (3.3)
Seated row maximal strength (kg)	88.1 (7.8)
Seated row relative strength	0.95 (0.04)

ers were used for this study, and therefore the paper is primarily descriptive in nature.

Subjects

The sample consisted of 8 elite male rowers who were training for the Olympics and were in a maximum strength phase of their training cycle. The land-based program comprised mostly bench presses, bench pulls and cable rows, squats, and Olympic lifts and their derivatives. The characteristics of the rowers are presented in Table 1. Subjects provided written consent for testing as part of their scholarship arrangements with the Australian Institute of Sport. Subjects were informed that they could withdraw from the study at any time without prejudice. The Human Subjects Ethics Committee of AUT University approved all procedures undertaken.

Procedures

Equipment. Subjects performed seated rows on a standard cable row machine. A rotary encoder (GymAware, Canberra, Australia) was attached to the machines pulley and measured weight stack displacement. Raw GymAware data consisted of time-stamped position points; the resolution of the time stamps was 1 ms. The maximum (best) resolution of the position encoder was 3 mm. These data were relayed to a Palm Pilot portable electronic device and uploaded to a web-based analysis program (<http://www.gymaware.com/site>).

Testing. Procedures used in this investigation were similar to those outlined in previous studies (24, 25). Testing was performed on 2 occasions separated by 2 days, the seated row simulating the on-water motion of the arms as much as practically possible. During the first session, the subject's 1RM was established on a standard cable row machine. Subjects sat on a fixed seat with feet on the machine's footplates, and the subject based on personal preference selected the degree of knee flexion. On a signal from the tester, the subject gripped (supinated) the cable row handle and moved his trunk into a vertical position, keeping arms fully extended. On a verbal signal from the tester, the lifter pulled the handle into his sternum. A lift was considered complete if the subject's wrists touched his rib cage and there was no flexion or extension

of the trunk during the trial. A 3- to 5-minute rest period was allowed between trials.

During the second session, subjects performed a single maximal effort trial (i.e., the handle was moved as "fast" as possible) in ascending order at 30, 40, 50, 60, 70, 80, 90, and 100% of their predetermined 1RM. The reliability of a single trial for each load was established during piloting (coefficients of variation of ~ 3 –5%). A 1-minute rest period was allowed between each trial. The criteria for a successful lift were identical to the 1RM testing. Prior to both sessions, subjects completed 5–10 minutes of submaximal stationary cycling and a series of submaximal lifts on the cable seated row machine followed by a 3–5 minute rest prior to testing. This type of methodology has been used previously (10).

Data Analysis. Standard biomechanical equations were used to calculate kinetic and kinematic variables from the displacement data. Only the concentric phase of the movement was investigated. The concentric phase of the row was determined as the time when bar velocity changed from zero to positive. The following variables were determined from the weight stack from its kinematic and mass characteristics during the concentric phase: duration of the concentric phase, time to peak force and peak power, average velocity, peak velocity, average force, peak force, mean power, and peak power.

Statistical Analyses

Due to the elite nature and hence size of the sample, most data sets violated assumptions regarding normality, equal variance, and statistical power. For this reason the statistical analysis is principally descriptive in nature. Concentric temporal, position, and force-velocity characteristics of the seated row across loads ranging from 30 to 100% 1RM were described using means and standard deviations, which were used throughout as measures of centrality and spread of data. To estimate the load that maximized mechanical power output, a quadratic was fitted to each subject's power output (W) vs. 1RM. The goodness-of-fit of the quadratic was expressed as an overall correlation coefficient (R^2) calculated by taking the square root of the fraction of the variance explained by the model, after adjusting for degrees of freedom. The curve was also used to estimate the percent decline in power output at loads of 10 and 20% 1RM either side of the maximum power output. These data are also presented as means and standard deviations.

RESULTS

The temporal characteristics associated with each load are described in Table 2. As load increased, so did the time under tension, as evidenced by a 40% increase in duration of the concentric contraction between 30 and

TABLE 2. Descriptives (mean $\pm$ SD) of seated row temporal characteristics across loads of 30–100% 1 repetition maximum (1RM).

Load (% 1RM)	Duration (s)	Time to peak force (s)	Movement time (%)	Time to peak power (s)	Movement time (%)
30	0.51 (0.04)	0.08 (0.04)	16.0 (7.40)	0.18 (0.02)	35.2 (2.53)
40	0.57 (0.10)	0.12 (0.10)	19.5 (12.2)	0.25 (0.10)	42.8 (7.94)
50	0.57 (0.10)	0.12 (0.07)	20.8 (11.2)	0.24 (0.08)	41.3 (10.5)
60	0.58 (0.05)	0.09 (0.07)	15.3 (10.1)	0.26 (0.10)	44.1 (13.2)
70	0.61 (0.04)	0.09 (0.04)	15.4 (5.67)	0.27 (0.04)	38.2 (17.4)
80	0.72 (0.16)	0.18 (0.21)	22.3 (16.9)	0.34 (0.15)	45.9 (9.97)
90	0.71 (0.06)	0.07 (0.05)	9.38 (7.27)	0.30 (0.09)	41.7 (11.3)
100	0.84 (0.16)	0.14 (0.14)	14.5 (10.9)	0.33 (0.14)	37.5 (9.10)

TABLE 3. Descriptives (mean $\pm$ SD) of seated row position characteristics across loads of 30–100% 1 repetition maximum (1RM).

Load (%) 1RM)	Displacement at peak force (m)	Movement displacement (%)	Displacement at peak power (m)	Movement displacement (%)
30	0.05 (0.03)	6.58 (4.16)	0.21 (0.04)	27.2 (4.91)
40	0.03 (0.02)	4.68 (3.57)	0.22 (0.04)	30.7 (3.80)
50	0.04 (0.03)	7.63 (5.77)	0.20 (0.08)	30.9 (11.2)
60	0.02 (0.01)	3.84 (2.56)	0.19 (0.05)	34.3 (13.6)
70	0.03 (0.02)	5.21 (3.52)	0.20 (0.03)	34.5 (5.97)
80	0.05 (0.04)	8.26 (7.89)	0.19 (0.06)	33.4 (7.92)
90	0.02 (0.02)	3.85 (5.29)	0.19 (0.08)	35.1 (11.1)
100	0.03 (0.02)	5.52 (2.88)	0.16 (0.05)	31.9 (7.98)

TABLE 4. Descriptives (mean $\pm$ SD) of seated row force-velocity characteristics across loads of 30–100% 1 repetition maximum (1RM).

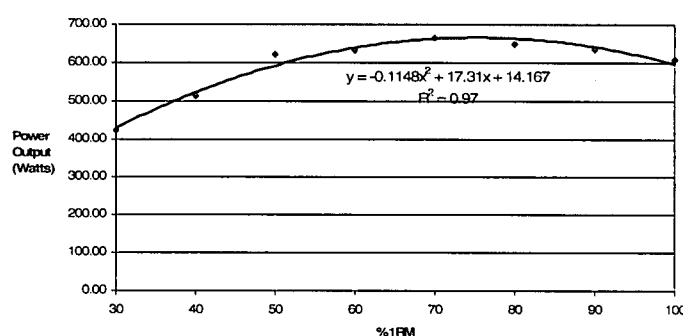
Load (%) 1RM)	Mean velocity (m·s ⁻¹)	Peak velocity (m·s ⁻¹)	Mean force (N)	Peak force (N)
30	1.50 (0.19)	2.48 (0.22)	246 (29.6)	620 (91.1)
40	1.35 (0.10)	2.23 (0.17)	327 (31.2)	761 (121)
50	1.11 (0.23)	1.87 (0.30)	417 (38.8)	887 (161)
60	1.00 (0.18)	1.59 (0.23)	505 (53.1)	921 (105)
70	0.98 (0.08)	1.47 (0.11)	588 (52.6)	998 (104)
80	0.85 (0.10)	1.26 (0.13)	677 (62.3)	1,077 (117)
90	0.73 (0.14)	1.07 (0.17)	759 (67.1)	1,163 (114)
100	0.64 (0.04)	0.96 (0.03)	841 (72.7)	1,176 (98)

100% 1RM. The time to peak force occurred early in the concentric phase, with all peak forces occurring within the first 25% of the concentric movement time. The time to peak power occurred later in the concentric phase for all loads (35.2–45.9% movement time). No clear load effect was observed with the time to peak force or power data.

The position characteristics associated with each load are detailed in Table 3. Peak force occurred early in the concentric phase, with all peak forces occurring within the first 8.3% of the movement. Peak power occurred later in the concentric phase for all loads, with most peak powers occurring within the first third of the movement. Once more no clear load effect was observed in terms of the position at which peak force or peak power occurred.

The force-velocity characteristics associated with each load can be observed in Table 4. As load increased there was a 2.3- and 2.6-fold decrease in mean and peak velocity, respectively, over the load spectrum. Associated with this decrease in velocity were a 3.4- and a 1.9-fold increase in mean and peak force, respectively. The time to peak velocity ranged from 0.25 ± 0.02 s to 0.39 ± 0.12 s and occurred within 45.7–59.6% of the start of the concentric phase for all loads. Once more no load effect was observed.

A representative power-load curve with the quadratic equation and goodness of fit (R^2) can be observed for mean power (Figure 1). The data represented in Tables 5 and 6 are the mean ($\pm$ SD) of the estimated load that maximized power output for the mean and peak power data of all subjects. In terms of mean power, an estimated load of 81.4% ($\pm 9.7\%$) 1RM was found to maximize power output. Individual maximal power outputs ranged from 69 to 100% 1RM. A 10 and 20% change in load each side of this maximum resulted in a 1.8 and 7.3% decrease in

**FIGURE 1.** Representative mean power-load curve for the seated row of 1 subject with the quadratic equation and goodness of fit (R^2) detailed.**TABLE 5.** Estimated mean ($\pm$ SD) loads (% 1 repetition maximum [1RM]) and power outputs (watts) at which maximum occurred for the mean power outputs of each subject. The percent changes and power outputs associated with a 10 and 20% change in 1RM load are also detailed with the corresponding goodness of fit (R^2).

		Power fall-off each side of maximum				
		10%		20%		
Maximum occurs at			%		%	
% 1RM	Power (W)	W	maxi- mum	W	maxi- mum	R ²
77	662	8.5	1.3	34.1	5.1	0.81
69	476	9.7	2.0	38.8	8.1	0.38
77	494	8.8	1.8	35.2	7.1	0.95
75	666	11.5	1.7	45.9	6.9	0.97
100	587	4.0	0.7	16.0	2.7	0.72
81	521	7.1	1.4	28.5	5.5	0.95
86	711	35.1	4.9	140.4	19.7	0.85
83	592	5.1	0.9	20.4	3.4	0.90
Mean = 81.4	589	11	1.8	45	7.3	0.82
SD = 9.7	87	10	1.3	40	5.3	0.20

power output, respectively. With regard to peak power, an estimated load of 57.2% ($\pm 12.9\%$) 1RM was found to maximize power output. Individual maximal power outputs ranged from 43 to 83% 1RM. A 10 and 20% change in load each side of this maximum resulted in a 1.4 and 5.6% decrease in power output, respectively.

DISCUSSION

Due to the absence of literature studying the repetition kinematics and kinetics of such exercises as the seated row, much of the discussion will be based on comparing the characteristics of this exercise to the bench press. In terms of the temporal characteristics, the duration of the concentric phase was very similar to bench press research at lighter loads. That is, concentric durations of 0.49 s (± 25 s), 0.59 s (± 24 s), and 0.68 s (± 11 s) have been reported for concentric bench presses at 40–45% 1RM bench press loads. However, there are marked differences between the duration of the concentric phase for the seated row and bench press at heavier loading intensities. For example, 1.12- to 1.54-s concentric durations have been reported for 80 and 90% 1RM loads, respectively (11, 25). These are approximately 0.5 s greater than the seated row times. It seems that the flexors (seated row) of the arm can move heavier relative loads in a quicker time than the extensors (bench press). This may be attributed

to architectural differences, which are discussed more fully later in this article.

Peak force was found to occur early in the concentric phase (0.07–0.18 s or 9.3–22.3% of movement time) with no noticeable load effect. Earlier peak forces have been reported elsewhere (24) for the concentric phase of a 45% 1RM bench press (0.10 s or 1.0% of movement time). However, it should be remembered that a countermovement preceded the concentric phase of this bench press, and it is well known that a preceding eccentric contraction potentiates kinematics and kinetics during the concentric contraction. Peak power occurred later in the concentric phase (0.18–0.34 s or 35.2–45.9% of movement time). These times appear to occur earlier than other data reporting the time to peak power for 40% 1RM (0.43–0.45 s), 60% 1RM (0.56–0.59 s), and 80% 1RM (0.72–0.78 s) loads (12).

With regard to displacement, peak force and peak power occurred within 0.05 m (<8.3%) and 0.22 m (<36%), respectively, from the beginning of the concentric phase for all loads. Research reporting the position at which peak force or power occurred is scarce. However, Newton and colleagues (24) reported that for a traditional bench press, peak velocity occurred 60% into the movement. This finding approximates the results of this study (45.7–59.6% across loads), suggesting that considerable displacement (~40–55%) is spent in deceleration during the seated row.

The force velocity characteristics (Table 4) of the seated row were as expected, an increase in load resulting in an increase in force and a concomitant decrease in velocity. The force-velocity relationship of muscle dictates that the faster the velocity of concentric muscle action, the lower the force that can be produced. This has been attributed to the increased rate of cross-bridge attach-detach cycling, which equates to less time to generate tension for force production (18) and greater internal resistance/viscosity that equates to loss of force (9). The increase in force output and decrease in velocity associated with increasing load for the seated row, were similar to those reported in other studies reporting the force-velocity-load spectrum for the bench press (10, 11, 25).

The flexion power outputs (seated row) were of interest in this study. However, most research in this area has studied extension power outputs using the bench press and its derivatives (2, 4, 11, 19, 22–26). Most of these researchers have reported loads of 30–60% 1RM because the intensities that maximize mean and peak power output and the loads reported to maximize power are similar regardless of subject training status, age, and the type of bench press motion used. These findings were different to this study, especially in terms of mean power output, because loads of ~57 and ~81% 1RM were found to maximize peak and mean mechanical power output, respectively, for the flexor task (seated row).

It has been suggested that power output might very well differ, depending on whether the task is a flexion or extension. For example, Edgerton and others (13), discussing the effects of muscle architecture, depicted maximum power output occurring at a range of isometric forces, depending on whether the knee extensors (45%), knee flexors (59%), plantar flexors (35%), or dorsiflexors (53%) are studied. Based on the *in vivo*, dynamic, multiarticular, power-load spectrum analysis used in this study, the findings of Edgerton and colleagues (13) are somewhat supported. That is, the loads that maximize mean mechanical power output ($81.4 \pm 9.7\%$ 1RM) for the flexor

TABLE 6. Estimated mean ($\pm$ SD) loads (% 1 repetition maximum [1RM]) and power outputs (watts) at which maximum occurred for the peak power outputs of each subject. The percent changes and power outputs associated with a 10 and 20% change in 1RM load are also detailed with the corresponding goodness of fit (R^2).

		Power fall-off each side of maximum				R^2
		10%		20%		
Maximum occurs at			%		%	
% 1RM	Power (watts)	Watts	maxi- mum	Watts	maxi- mum	
43	1,243	8.4	0.7	33.8	2.7	0.65
61	1,016	17.4	1.7	69.7	6.9	0.45
60	901	9.6	1.1	38.4	4.3	0.68
56	1,273	15.6	1.2	62.5	4.9	0.94
61	1,004	9.3	0.9	37.1	3.7	0.84
49	989	6.4	0.6	25.6	2.6	0.63
83	1,237	50.1	4.1	200.4	16.2	0.68
43	1,220	11.9	1.0	47.5	3.9	0.87
Mean = 57.2	1,110	16	1.4	64	5.6	0.72
SD = 12.9	147	14	1.1	57	4.5	0.16

task (seated row) were considerably higher than those reported previously for the extensor (bench press 30–60% 1RM). Furthermore, it seems that there are minimal decreases in power output for 10% 1RM (–1.8% or –7.3 watts) and 20% 1RM (–7.3% or 44.9 watts) each side of the load that maximizes mean power output. Lesser decreases can be observed for the peak power data (Table 6). Researchers studying the bench press have also found that loads either side of the load that maximizes mechanical power output were not significantly different (4, 11).

The reasons for these differences can only be speculated upon but could be attributed to muscle architecture, function, and training status. It is well known that differences in muscle fiber length, muscle fiber type, muscle cross-sectional area, and muscle attachment points affect the range of motion, velocity, maximum force, force length, force velocity, torque velocity, and shape of the torque-angle relationship. For example, Edgerton and others (13) attributed the differences between extensor and flexor power output to the different fiber lengths, because power output is related to fiber shortening velocity, which in turn is related to the number of sarcomeres arranged in series (fiber length). The elbow flexor (biceps brachii, brachialis, and brachioradialis) muscle fibers for the most part extend parallel to the muscle force-generating axis and have relatively long fiber length-to-muscle length ratios compared with the elbow extensor triceps brachii. This increases the active range of the length tension relationship and also causes an increase in the muscle's absolute maximum contraction velocity (21). An and colleagues (1) indicated that the moment arms from the biceps brachii, brachialis, and brachioradialis increase 2.3-, 3.5-, and 1.7-fold, respectively, when the elbow traveled from a fully extended position to 100° flexion. In contrast, the moment arm for triceps brachii increased 1.3-fold when traveling from 100° flexion to extension. It has even been shown that the 3 major flexors of the elbow have different architecture and therefore different force-velocity capabilities. Furthermore, it has been shown that the force-length properties of human skeletal muscle can and will adapt to chronic functional requirements, as evidenced in elite cyclists and runners (17). The combination of these factors with the large phys-

iological cross-sectional area of the elbow flexors may in some part explain the differences in maximum power output between exercises and/or the difference between the elite rowers of this study and other athletic populations.

PRACTICAL APPLICATIONS

Most research in this area uses novice, student, or relatively untrained subjects. This study used elite athletes with a substantial training background to profile the kinematics and kinetics of the seated row. Such an approach has advantages and disadvantages. For example, establishing normative data or describing the kinematics and kinetics of an exercise and using these data for talent identification or the setting of training goals are advantages. However, the practicality of working with an elite sample is that the sample size is typically small, and hence assumptions regarding normality, equal variance, and statistical power are violated. Even though standard inferential statistics could not be used as a result of this sample size, we still feel the information is of great value and has a number of valuable training implications for strength and conditioning coaches. The reader needs to be cognizant of the limitations of such an approach in particular in terms of the generalization of findings to a larger population.

Weight-training exercises, such as the seated row, form the basis of many land-based training plans. However, very little is known about the force-time characteristics, the load or loads that maximize mechanical power output, the effect of varying training intensity, or the specificity of these weight-training exercises to sporting activities (e.g., rowing). This study has to some extent contributed to the knowledge in this area but also acknowledges the need to analyze the specific activity, such as the on-water characteristics of the rowing stroke and match profiles thereafter. For example, many coaches request that the weight-training exercises "look" or "feel" like the sport to the athlete. Some movements may look like rowing but may differ to the acceleration profile of the row ergo or on-water rowing performance. It may be that for single-joint and/or multijoint exercises relevant to rowing, to match forces or power for single joint exercises, heavier loads are used, and for multijoint exercises it might necessitate the use of low loads in training. Or if the end point of the stroke (oar chest) is a critical point of force application, maybe bench pulls allow better improvement in force production near the chest because a great deal of deceleration (40–55% of movement) is associated with the seated row across the load spectrum.

In terms of power output, much emphasis is based upon finding exercises and determining loads that maximize mechanical power output. One of the major findings of this study was that the load that maximized mean power output for a flexor activity, such as the seated row (~80% 1RM), was higher than those loads published for extensor activities, such as the bench press (30–60% 1RM). Whether this is the result of different muscle architecture or the training status of this particular sample can only be speculated. Future research needs to examine profiles of both the flexor and the extensors in a single paradigm.

It would seem that the predilection of researchers or coaches to train all subjects at 1 load (e.g., 30% 1RM) is fundamentally flawed due to interindividual maximum power differences, as observed in this study. That is, even though the mean load that maximized mechanical power

output for the rowers was approximately 81%, the individual maximal power outputs ranged from 69 to 100% 1RM. Furthermore, the importance of mean and/or peak power to the athletic task of interest needs to be considered because the load that maximizes each variable is quite different (e.g., ~81% 1RM vs. 57% 1RM). Training for maximum power needs to be individualized, constantly monitored, and adjusted because research suggests that it is transient.

The practical significance of identifying the load that maximizes mechanical power output would seem debatable. Some research and also the findings of this study suggest that training at loads (% 1RM) either side of the load that maximizes power output does not change power output substantially. The functional significance of training at these loads with such minimal changes in power output per repetition once more can only be speculated.

The challenge, then, for many sports is in matching the force-velocity power profiles of the weight-training exercise to the sporting activity. Such an approach may optimize transference of gym-based strength and power gains to performance. The kinematics and kinetics of the seated row generated in this study hopefully offer "food for thought" for conditioners and sport scientists alike, by improving conditioning practice to some degree and providing the framework for applied sport science research in this area.

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