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Research article

THE IMPORTANCE OF ISOMETRIC MAXIMUM STRENGTH IN COLLEGE WRESTLERS

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ABSTRACT

Previous research has demonstrated the importance of isometric maximal strength (PF) and rate of force development (RFD) in a variety of athletic populations including track cyclists and track and field athletes. Among coaches and sports scientists there is a lack of agreement regarding how much strength is required for optimal performance in most sports. The purpose of this study was to examine relationships between measures of PF, RFD and one repetition maximum (IRM) strength with other variables that might contribute to successful performance in collegiate wrestlers. Eight men (M = 20.0, SD = 0.4 years; Height M = 1.68, SD = 0.13 m; Mass M = 78.0, SD = 4.2 kg) who were Division III college wrestlers participated in this study. They were tested for PF using the isometric mid thigh pull exercise. Explosive strength was measured as RFD from the isometric force-time curve. The IRM for the squat, bench press and power clean exercises were determined as a measure of dynamic strength. Vertical jump height was measured to determine explosive muscular power. The wrestlers also ranked themselves and the coaches of the team also provided a ranking of the athletes. Correlations between the variables were calculated using the Pearson product moment method. Results indicated strong correlations between measures of PF and IRM ($r = 0.73 - 0.97$). The correlations were very strong between the power clean IRM and PF ($r = 0.97$) and squat IRM and PF ($r = 0.96$). There were no other significant correlations with other variables apart from a strong correlation between RFD and coaches ranking ($r = 0.62$). Findings suggest that isometric mid thigh pull test does correlate well with IRM testing in college wrestlers. RFD does not appear to be as important in college wrestlers. The isometric mid thigh pull provides a quick and efficient method for assessing isometric strength in athletes. This measure also provides a strong indication of dynamic performance in this population. The lack of strong correlations with other performance variables may be a result of the unique metabolic demands of wrestling.

KEY WORDS: Isometric strength, wrestling, power.

INTRODUCTION

Wrestling is a high intensity sport which requires strength and power of both the upper and lower body as well as relying heavily on isometric force for the various wrestling techniques (Callan et al., 2000;

Kraemer et al., 2001; Utter et al., 1998). Two different forms of wrestling are contested at the Olympic Games. In Greco-Roman competition, wrestlers use only their arms and upper bodies. In freestyle competition, wrestlers also use their legs and may hold opponents above or below the waist.

As a combative sport, both forms of wrestling place unique metabolic stresses on the body (Kraemer et al., 2004; Nemet et al., 2004; Utter et al., 1998). For example the blood lactic acid concentrations in response to a wrestling match can be over 19 mmol.l⁻¹ (Kraemer et al., 2001). Therefore, the sport of wrestling is one of the most demanding sports from a metabolic perspective and it is a sport where the requirement of absolute strength and power is critical (Kraemer, 2002; Utter et al., 2002).

Previous research has demonstrated the importance of isometric maximal strength (PF) and rate of force development (RFD) in a variety of athletic populations including track cyclists (Stone et al., 2004), track and field athletes (Stone et al., 2003b) and weightlifters (Stone et al., 2005). A number of studies have investigated the strength and power characteristics of different types and skill levels of wrestlers (Hakkinen et al., 1984; Silva et al., 1981; Utter et al., 1998, 2002). However there has been limited emphasis placed on relating these force measurements to actual indices of performance. Among coaches and sports scientists there is a lack of agreement regarding how much strength is required for optimal performance in most sports (Stone et al., 2002). However, available data do suggest that the importance of maximum isometric strength is underestimated in a variety of athletic populations (Stone et al., 2003a; 2003b; 2004).

The purpose of this investigation was to examine the relationships between measures of PF, RFD and one repetition maximum (1RM) strength with other variables that might contribute to successful performance in collegiate wrestlers.

METHODS

Participants

Eight men were recruited from the University of Wisconsin-La Crosse (NCAA Division III) wrestling team and served as subjects in this investigation. Subject characteristics were as follows (mean \pm SD): Age 20.0 \pm 0.4 years; Height 1.68 \pm 0.13 m; Mass 78.0 \pm 4.2 kg. All the subjects were lower ranked, underclassmen members of the team following the same training programme which involved 4 resistance training sessions each week and approximately 2-3 hours of wrestling each week. The wrestlers were currently out of season when they were tested and were following an off-season conditioning programme, meaning wrestlers were not regulating their bodyweight at the time of testing. Participants were informed of the potential risks and gave their written informed consent to participate prior to beginning the study. The

University's Institutional Review Board for use of human participants approved this study.

Experimental procedures

The following testing battery was administered to the wrestlers over a two day period. All athletes were familiarized with the tests prior to completing the testing sessions.

Isometric strength assessment

Isometric strength assessment involved testing PF using the isometric mid-thigh pull exercise (Haff et al., 1997; Stone et al., 2003b). The mid-thigh pull was executed on an isometric rack placed over a Quattro Force plate (Kistler Instrumente AG, Winterthur, Switzerland) which was sampled at a rate of 500 Hz. Participants were instructed to pull on the immovable bar as quickly as possible and were required to maintain effort for 5 seconds. It has been suggested that instructions stated as "hard and fast" produce optimal results for recording maximal force and RFD (Bemben et al., 1990; Haff et al., 1997; Sahaly et al., 2001). Participants performed 3 5 sec trials and were allowed 2 min of rest between sets. The highest value of the three trials was used for later analysis. The bar height was adjusted at 2 cm increments so that the knee angle was 130 degrees (straight leg = 180 degrees). Force-time curves were analysed during the mid thigh pull. The variables that were analysed included isometric RFD and isometric PF. The test-retest reliabilities (intraclass correlation, ICC) of these tests were $r \geq 0.96$.

Dynamic strength assessment

The 1RM for the back squat, bench press and power clean exercises were determined as a measure of dynamic strength. In the case of the back squat and bench press, multiple warm-up trials were given prior to actual 1RM testing as previously validated by Wilson et al. (1993). These consisted of 10 repetitions at 30% followed by 2 min rest, 7 repetitions at 50% followed by 2 min rest, 4 repetitions at 70% followed by 3 min rest, 1 repetition at 90% followed by 3 min rest (% are given of participant estimated 1RM obtained through use of an Eppley chart). From the last warm-up set, loading was increased through participant feedback on level of repetition intensity so that 1RM was achieved within 3 trials. Four minutes of rest was given between each 1RM effort. The squat exercise required the participants to rest the bar on their trapezius and the squat was performed to the parallel position, which was defined as when the greater trochanter of the femur was lowered to the same level as the knee. The participant then lifted the weight until their knees

were fully extended. Bench press testing was performed in the standard supine position. The participant lowered the bar to mid-chest, and then pressed the weight until the elbows were fully extended. No bouncing of the weight was permitted. The reliability of this method of 1RM testing in our laboratory is high (ICC = 0.98).

The testing method for the power clean exercise was slightly different due to the nature of the activity as compared to the back squat and bench press. As in the case of the other exercises, participants were given multiple warm-up trials prior to 1RM testing (% are given of participant estimated 1RM), 2 sets of 5 repetitions at 60% with each followed by a 2 min rest, 3 repetitions at 80% followed by a 3 min rest, 1 repetition at 90% followed by a 4 minute rest. From the last warm-up set, loading was increased through participant feedback on level of repetition intensity so that 1RM was achieved within 3 trials. Four minutes of rest was given between each 1RM effort. An acceptable lift was determined by the athlete being able to catch and hold the bar in a steady position for 5 seconds. Participants were familiar with the testing procedure because of its similarity to the testing they are exposed to as part of their sport.

Vertical jump

Vertical jump height was measured to give an indication of explosive muscular power (Canavan and Vescovi, 2004). Each participant performed three trials with the highest jump height used in the data analysis. The following procedures were followed for each trial: 1) the participant was instructed to remain motionless for 2 seconds before performing the jump trial; 2) the participants were instructed to place their hands on their hips and to self-select their depth for a countermovement jump upon being given a verbal signal; 3) upon conclusion of one repetition, the participant was instructed to stand motionless for 2 seconds. Data collection for the trial was then terminated. Trials were repeated if individuals did not land onto the force platform from the vertical jump. Two minutes of rest-time was allowed between each trial throughout the testing session. Jump height was calculated using flight time and the standard Bosco equations.

Ranking

The wrestlers ranked themselves and the coaches of the team also provided a ranking of the athletes. Both the participants and coaches were asked to

provide a ranking on a 0 – 100 scale based on their actual wrestling performance in the most recent competitive season. Both participants and coaches were instructed to base their ranking entirely on performance and not on potential or work ethic. Taylor et al. (1987) found a strong correlation between an athletes self perception and their performance in a variety of sporting events including basketball, tennis, and track and field events. In addition, the use of coach ranking as a predictor of in-game athletic performance was validated by Marey et al. (1991) who discovered a strong (0.74) correlation between performance in coaches ranking of collegiate volleyball athletes.

Statistical analyses

Correlations between the variables were calculated using the Pearson product moment correlation coefficient. Hopkins (2004) and Cohen (1988) have ranked the meaningfulness of correlations as r = trivial (0.0), small (0.1), moderate (0.3), strong (0.5), very strong (0.7), nearly perfect (0.9), and perfect (1.0). The criterion for statistical significance of the correlations was set at $P \leq 0.05$.

RESULTS

The average results for the testing variables are shown in Table 1. There were very strong significant correlations between measures of PF and 1RM ($r = 0.73 - 0.97$) ($p \leq 0.05$). The correlations were nearly perfect between the power clean 1RM and PF ($r = 0.97$) and squat 1RM and PF ($r = 0.96$). There were no other significant correlations with other variables apart from a strong correlation between RFD and coaches ranking ($r = 0.62$).

DISCUSSION

Previous research has demonstrated the critical role of isometric strength to performance across a range of different sports (Stone et al., 2003b; 2004; 2005). The results of this study indicate that in collegiate wrestlers the isometric mid thigh pull test does correlate well with 1RM testing. However, RFD was shown to be not as critical in these athletes. These results suggest that isometric testing provides a good indication of an athlete's dynamic performance during 1RM testing, for both the back squat and power clean exercises.

A wrestling match consists of a series of dynamic movements of the legs, hips and back and

Table 1. Descriptive statistics for physiological test results (n = 8). Data are means (\pm SD).

Power Clean (kg)	Squat (kg)	Bench Press (kg)	PF (N)	RFD (N·s ⁻¹)	Vertical Jump (cm)
85 (15)	129 (23)	105(19)	2645 (465)	32063 (18834)	45 (4)

also involves isometric grasping for position maintenance. Research by Kraemer et al. (Stone et al., 2002) has shown that these patterns of muscular force appear sensitive to the accumulated effects of fatigue i.e. muscle damage or acid-base balance. Lower body power has previously been shown to be important for freestyle wrestling (Callan et al., 2000). One study by Silva et al. (1981) showed no differences in isometric grip strength between successful and less successful wrestlers competing for a junior world games team. The values obtained for PF in the present study were lower than values that were found for Division I wrestlers (Utter et al., 1998) (2645N vs. 2950N). This previous research indicates that greater strength is advantageous for successful wrestlers. One additional factor that needs to be considered along with the metabolic demands of this sport is the weight class restrictions. It is clear that this combative sport is a unique event and a number of different physiological characteristics contribute to successful performance.

We did not find a strong relationship between RFD and measures of strength and performance in this study. However, RFD may be an important performance variable to study within wrestlers because explosive exercises tend to enhance the ability to generate high RFD (Aagaard et al., 2002; Kyrolainen et al., 2005; McBride et al., 2002). In one study Hakkinen et al. (1984) evaluated the neuromuscular, anaerobic, and aerobic performance characteristics of elite Finnish wrestlers. In this small sample ($n = 3$) the athletes were found to have high peak RFD's although this was not correlated with performance. Interestingly, the values obtained in the present investigation for peak RFD ($32\ 063\ \text{N}\cdot\text{s}^{-1}$) were similar to values obtained for the Finnish wrestlers ($31\ 065\ \text{N}\cdot\text{s}^{-1}$) and higher than those achieved by Division I collegiate wrestlers ($17\ 815\ \text{N}\cdot\text{s}^{-1}$) (Utter et al., 1998). This provides further evidence that RFD may not be as important as maximum strength for this population.

The vertical jump test is a simple and reliable test that can provide useful information about the power and performance of athletes (Canavan and Vescovi, 2004). However, it should be noted that the values obtained for these Division III collegiate athletes were considerably lower than values found in more elite performers (Callan et al., 2000). For example, the 1997 U.S. freestyle wrestling world team averaged 60 cm (Callan et al., 2000) whereas the athletes in this investigation averaged only 45 cm, a finding that should not be surprising given the lower level of these athletes and the relative importance of power to performance.

The major limitation of the present study is the

small number of participants who were tested. In addition, other physical characteristics such as body composition were not tested. Aerobic capacity has also been shown to be quite high in elite wrestlers (Callan et al., 2000) and this may have provided interesting information about the training level of these participants. However, it has been suggested that aerobic capacity is not a major determinant of success in elite wrestlers (Yoon, 2002). Measures of muscular endurance may have also provided useful information regarding these participants. Another limitation is that the in-season performance on the wrestlers could not be determined as the testing was conducted in the off-season.

Maximum strength appears to be a major factor influencing performance in a variety of different sports (Stone et al., 2004). It has been previously shown that absolute strength and power are an important component of wrestling (Kraemer et al., 2001; 2004). It seems conceivable that given the nature of wrestling where competitors are often placed in situations where strength is competing against strength, the ability to exert maximum muscular force is more important in wrestling than the ability to exert force in an explosive manner. Previous work has demonstrated that isometric strength is attenuated with a wrestling match and over the course of a tournament (Kraemer et al., 2001). Specific isometric actions that will enhance hand grip strength in addition to upper body isometric strength would potentially be an important part of an elite wrestlers training program (Kraemer et al., 2004; Rezasoltani et al., 2005).

CONCLUSION

The sport of wrestling is a unique combative sport that places high metabolic demands on the body. Wrestling is a sport that requires high levels of both strength and power. The isometric mid thigh pull test does correlate well with 1RM testing, both in the back squat and power clean, in college wrestlers. RFD does not appear to be as important in college wrestlers. The isometric mid thigh pull provides a quick and efficient method for assessing isometric strength in athletes. Given that isometric strength may potentially differentiate between successful and less successful athletes (Stone et al., 2002), this test can provide important information in the strength diagnosis of wrestlers. This measure also provides a strong indication of dynamic performance in this population. The lack of strong correlations with other performance variables may be a result of the unique metabolic demands of wrestling.

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KEY POINTS

- In Division III collegiate wrestlers the isometric mid thigh pull test correlates well with 1RM testing.
- Rate of Force Development does not appear to be as important in college wrestlers.
- The lack of strong correlations with other performance variables may be a result of the unique metabolic demands of wrestling.

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