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ON THE PLYOMETRIC NATURE OF OLYMPIC WEIGHTLIFTING BIOMECHANICAL CONSIDERATIONS FOR PRACTICAL APPLICATIONS IN STRENGTH AND CONDITIONING FOR SPORT

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Abstract:
Olympic-style weightlifting exercises have found their place in the training of speed and power athletes. A systematic review of the most accredited academic literature provides kinetic and kinematic data to define the relationship between change in vertical ground reaction force (GRF), peak vertical bar velocity, average joint angular displacement and average joint angular velocity during the snatch, clean and jerk. Important similarities between jumping mechanics - the paradigm of power development in sport - and the pull in Olympic weightlifting have provided insight on the plyometric nature of these explosive movements, supporting the use of full lifts - snatch, clean and jerk - in the training of elite level athletes.

Keywords: snatch, clean and jerk, weighted pull, speed, power, agility

Introduction

Olympic-style weightlifting exercises have found their place in the training of speed and power athletes. Evidence in the most recent academic literature seems to suggest underlying similarities between performance in Olympic weightlifting and performance in sports (Storey & Smith, 2012; Hori, et al., 2008); however, the assumption that Olympic-style weightlifting derivatives - hang pulls and high pulls, shrugs and hang snatch, clean and jerk - can be as effective, if not more effective, in improving performance on the field and on the court of play (Suchomel, Comfort, & Stone, 2015) has resulted in a tendency to overlook some of the "*unique aspects in competitive weightlifting*" that can further benefit the development of well-rounded athletes (Storey & Smith, 2012). A better understanding of the nature of these explosive movements can provide more insights on the use of Olympic-style weightlifting exercises and their derivatives in the training of athletes.

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Method

A systematic review of the most accredited academic literature provides kinetic and kinematic data to define the relationship between the change in vertical ground reaction force (GRF), peak vertical bar velocity, and the average joint angular displacement and angular velocity during the pull in Olympic-style weightlifting. A comparison between the biomechanical characteristics of the second pull in Olympic weightlifting and jumping mechanics provides a rational explanation for the positive transfer of training between Olympic-style weightlifting exercises and performance in activities involving sprinting, jumping and changing direction.

Results

During the transition between first pull and second pull in the snatch, clean and jerk knees bend under load of approximately 16.2 ± 6.64 degrees while the angle at hips progressively increases from 89.5 ± 2.47 degrees of flexion (with an angle at the knee joint of approximately 134 ± 7.59 degrees) to 58 ± 2.47 degrees of flexion (with an angle at the knee joint of approximately 117.8 ± 6.62 degrees). As knees are extending during the liftoff, vertical GRF peaks right before hamstrings and glutes undergo a time of vigorous, violent eccentric contraction while their proximal insertion stays still to preserve the angle at the hip joint. This eccentric muscle action terminates as soon as the hips start to extend and vertical GRF temporarily decrease; the transition between first pull and second pull only lasts for approximately 0.148 ± 0.015 seconds and it initiates the fast, concentric, muscle action of the lower extremities that results in a sudden increase in vertical bar velocity. From the power position, a higher degree of angular velocity at the hip joint compared to the knee joint - maximum hip extension velocity during the second pull of 460.7 ± 27 degrees·s^{-1} compared to maximum knee extension velocity during the second pull of 390 ± 49.4 degrees·s^{-1} - reveals a higher contribution of hamstrings and glutes over quadriceps, as a consequence of the stretch-shortening cycle taking place during the second knee bent (Kipp, Redden, Sabick, & Harris, 2012; Gourgoulis, et al., 2002). This pattern confirms the proximal-to-distal activation sequence in the lower extremity described by Bobbert and van Ingen Schenau (1988) as the blueprint of power development in sports. Both kinetic and kinematic between the pull in Olympic weightlifting and jumping mechanics are further supported by the absolute level of peak power output and peak vertical bar velocity (compared to peak vertical velocity of the athlete center of gravity as measured in the countermovement vertical jump) achieved at the end of second pull, with approximately 3000 N of vertical ground reaction force and bar velocity ranging between 1.32 and 1.89 m/sec (Nagano, Komura, & Fukashiro, 2007; Linthorne, 2001; Garhammer, & Takano, 1992)

Discussion

Previous investigations have failed to provide a kinematic model to describe the relationship between snatch, clean and jerk, and jumping mechanics (Canavan, Garrett, & Armstrong, 1996). Peak power output has long been considered as the main criteria to determine some degree of similarities between the pull in Olympic weightlifting and performance in sport. However, this approach originally proposed by Garhammer and Gregor in 1992 (Garhammer, & Gregor, 1992) has eventually led to abandon the practice of competition lifts in favour of less complex, easier to learn variations of these movements such as pulls, high pulls, and power shrugs (Suchomel, Comfort, & Stone, 2015). By comparing the biomechanical model of the pull in Olympic weightlifting originally proposed by Enoka (1979), Takano and Garhammer (1992) with the most recent data describing the change in vertical GRF, peak vertical bar velocity, average angular displacement and average angular velocity at the hip and knee joint during the snatch, clean and jerk (Kipp, Redden, Sabick, & Harris, 2012; Hydock, 2001; Garhammer, & Takano, 1992) it is possible to define important similarities between these explosive movements and the jumping mechanics, the paradigm of athletic performance in speed and power events (Marques, & Izquierdo, 2014; Aoustin, & Formalskii, 2013; Linthorne, 2001; Umberger, 1998). Above and beyond the traditional distinction between first and second pull, the mechanics in Olympic weightlifting can further be described in terms of amortization phase, transition phase and concentric phase (Komi, 2003). This model provides important similarities between the snatch, clean and jerk - the competitive lifts in the sport of weightlifting - and jumping mechanics, validating the theories on the plyometric nature of Olympic weightlifting. The active transition between first and second pull - less than 160 m/sec, the average coupling time in high powerful, plyometric activities as original confirmed by Bosco, Viitasalo, Komi, and Luhtanen (1982) - requires the amortization of an increasing amount of downward vertical GRF resulting from the quasi-linear vertical displacement of the bar. The violent, eccentric muscle action of the musculature of the lower extremities results in the accumulation of elastic energy that is promptly utilized from the power position to increase peak vertical bar velocity. This dampening mechanics, for the most part lost when lifts are initiated from the power position - omitting the first pull - closely resemble the amortization phase in jumping mechanics (Moolyk, Carey, & Chiu, 2013) as confirmed by the significant similarities between the power position in Olympic weightlifting and the take-off position in jumping mechanics. Knee and hip joint position at the beginning of the second pull (approximately 70 degrees of knee flexion and approximately 55 degrees of hip flexion) correspond with the knee and hip angle at the takeoff in jumping mechanics: approximately 70 degrees of knee flexion and 55 degrees of hip flexion, a position that has been shown to provide the most significant mechanical advantage in the development of peak power output. These findings have been previously validated in practical and mathematical models based on vertical jump mechanics, depth jump mechanics and sprinting mechanics, especially within the 10-30m distances more often common in sports (Struzik, Konieczny, Stawarz, Grzesik, Winiarski, & Rokita, 2016). Therefore, it seems reasonable to consider how the plyometric nature of Olympic weightlifting is inherent to the active transition from first to second pull whereas movements initiated at the power position (see hang power snatch and hang power clean, pulls and high pulls) rely on the ability to create a high level of starting strength without taking full advantage of the physiological stretch-shortening cycle involved in athletic-like activities.

Conclusion

Average knee and hip angular displacement in the snatch, clean and jerk has never been studied as a function of the different distribution of GRF and relative change in bar velocity during the entire pull. Models describing both kinetic and kinematic evaluation of the pull in Olympic weightlifting have been derived from hang power snatch and hang power clean without taking into consideration the different distribution of vertical GRF throughout first and second. This review provides a mechanical model that can be used to describe important kinetic and kinematic similarities between snatch, clean and jerk and jumping mechanics, the paradigm of power development in sports. These findings confirm the plyometric nature of Olympic-style weightlifting exercises, encouraging the use of full lifts (competition lifts) rather than Olympic-style weightlifting derivatives in the training of speed and power athletes.

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