THE EFFECT OF SUBMAXIMAL LOADS ON TRUNK POSTURE DURING THE CLEAN IN COMPETITIVE WEIGHTLIFTERS

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The purpose of this study was to investigate the effect of submaximal loads on trunk posture during the clean in the aid of improving the technical and physical training of weightlifters. Weightlifters (n=10) with at least two years of training experience in weightlifting participated the study. Each participant performed 3 cleans at 65, 75, 85% of one repetition maximum (1RM). The results of this study highlighted the importance of a controlled trunk motion during the first pull followed by a maximal extension of the trunk in the second pull in relation to weightlifting performance. This study provided novel information about important technical aspects in weightlifting.

KEYWORDS: weightlifting; kinematics; kinetics; trunk; ground reaction forces

INTRODUCTION: Olympic weightlifting involves two barbell lifts, the snatch and the combined lift of the clean and jerk. The goal of weightlifting is to lift the greatest mass overhead under restrictions and strict rules of the event. During the clean the barbell is lifted from the floor to the shoulders in one continuous movement which requires the optimal control and coordination of different phases of the lift. Biomechanical analysis has provided in-depth understanding on weightlifting technique via the assessment of kinematic and kinetic relationships to understand and improve competitive performance (Enoka, 1979). However, these studies were limited to a single load (i.e. 85% 1RM), and predominantly focused on the snatch lift. In addition, studies tend to analyse lower extremity kinematics, yet the analysis of trunk posture during the clean lift is scarce (Enoka, 1979; Ono, Kubota, & Kato, 1969; Baumann, 1988; Kipp et al., 2012). The importance of trunk posture throughout a lift is evident in the knowledge of coaching cues. For example, the trunk should be held at a relatively constant angle in relation to the ground during the first pull, continue to extend in the transition phase and reach the absolute maximum extension in the second pull (Stone, Pierce, Sands, & Stone, 2006). The importance of a stable and synchronised motion between the trunk and hip during the first pull, a rapid movement of the hip and knee joints and the full extension of the trunk during the second pull in relation to lift mass has been highlighted (Kipp et al., 2012). Although, kinematic and kinetic data were acquired during all loads, only data from the final set at 85% of 1RM was considered for analysis, because weightlifting technique stabilises at loads heavier than 80% of 1RM, the 85% load was used to represent competitive weightlifting performance (Kipp et al., 2012). Using sub-maximal loads is extremely important in the development of strength and speed characteristics. Therefore, the purpose of this current study was to identify the effect of sub-maximal loads on trunk postures and force production during the clean in the aid of developing better understanding of correct lifting techniques.

METHODS: Ten trained (4 males, 6 females) competitive weightlifters participated in this study (mean ± SD height: 1.73 ± 0.07 m; mass: 78.0 ± 14.0 kg; 1-repetition maximum (RM) clean: 97.0 ± 28.0 kg). Ethical approval was granted by the University Research Ethics Committee. Reflective markers (14mm) were attached to the participants and to each end of the barbell to track barbell trajectory (Cappozzo et al., 1995). A 17-camera motion capture system (VICON, Oxford, UK) collected marker coordinate data at 200 Hz. Simultaneously, two AMTI-OR6 force platforms (Advanced Mechanical Technology, Inc., MA, USA) collected kinetic data at 1000 Hz. Three trials of the clean lift were collected at 65%, 75% and 85% of the 1RM 3 minutes recovery between each load. Kinematic and kinetic data were using a fourth-order, low-pass Butterworth filter with cut-off frequencies of 6 Hz and 25 Hz, respectively (Kipp et al., 2012). The following parameters were analysed and are considered important in relation to weightlifting performance: thorax angle, knee and hip (thorax relative to thigh) joint angle and vertical ground reaction force (vGRF). All kinematic and kinetic data was time normalized to 100% from the time the barbell broke contact with the ground until peak knee flexion in the catch position. Moment data was normalised to body mass. Primarily, group data has been considered for analysis, secondarily, Participant 1 (P1) and Participant 2 (P2) data has been analysed due to the similarities in their anthropometric measures (mean ± SD height: 1.73 ± 0.07 m; mass: 82.5 ± 2.12 kg).

RESULTS: Kinematic and kinetic data was analysed for the Group (Figure 1a/b/c/d) and P1 and P2 individually (Figure 2a/b/c/d/e/f/g/h). A slight change in trunk angle and an increase in knee angle has been captured during the first pull (Figure 1a/b; Figure 2a/b/e/f). At the point where the knee reached maximal extension, the trunk also extended slowly to its maximum (Figure 1a/b; Figure 2a/b/e/f). Peak ground reaction force (GRF) measures were observed during the second pull (Figure 1d; Figure 2d/h). The thorax extension was greater at 85% of 1RM than at 65% and 75% (Figure 1a; Figure 2 a/e). The standard deviation data (SD) suggested high variability in performance within the group (Figure 1 and 2 shaded area).

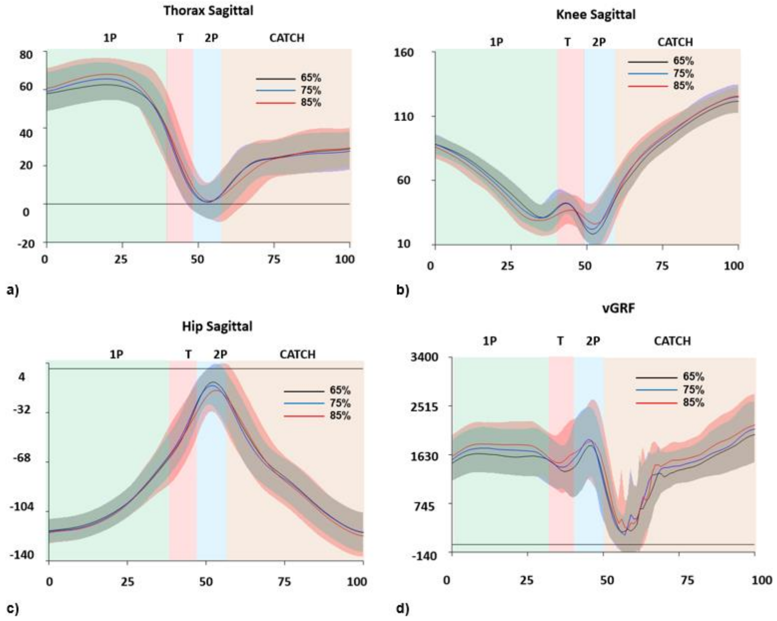
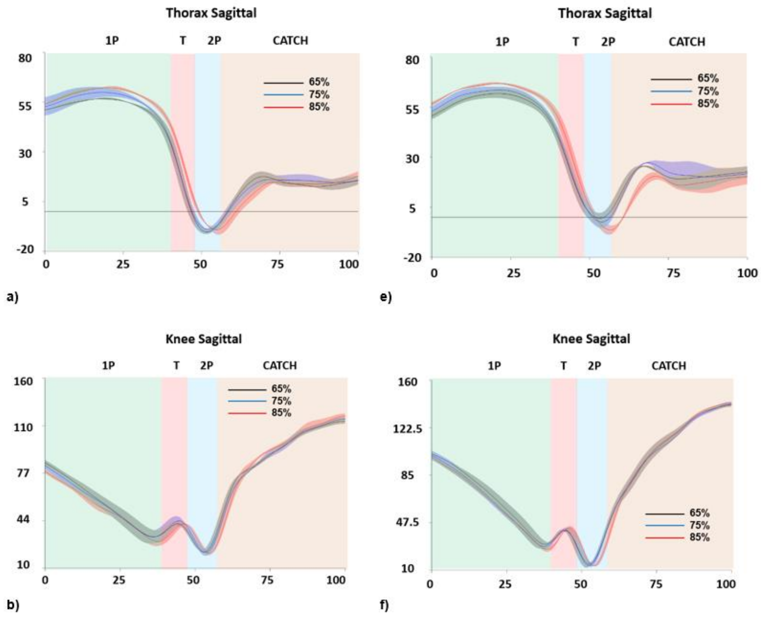


Figure 1. Group data: a) Thorax angle; b) Knee angle; c) Hip angle; d) Ground reaction force; The shaded area (standard deviation (SD)) demonstrates the fluctuations between loads at 65%, 75%, 85%.



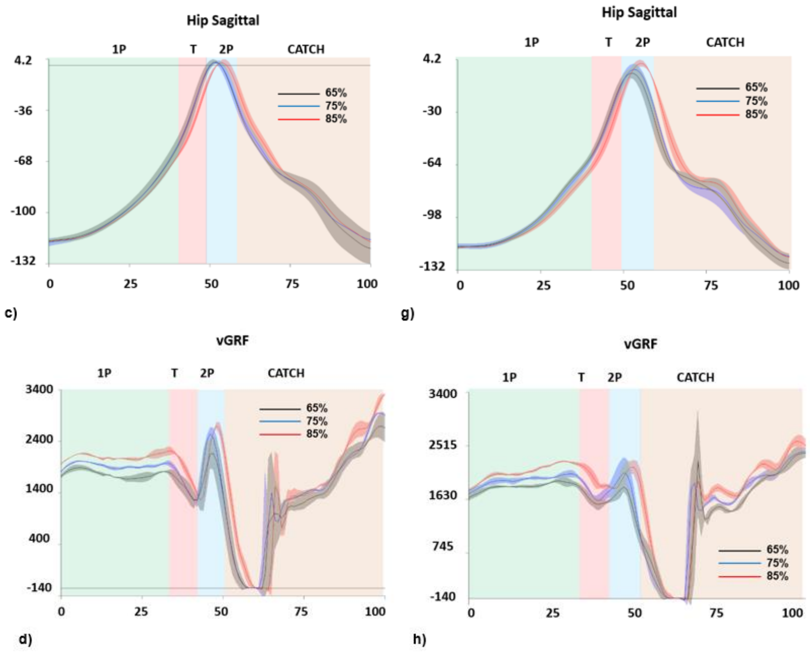


Figure 2. Individual data: a) Participant 1 (P1) Thorax angle; b) P1 Knee angle; c) P1 Hip angle; d) P1 Ground reaction force e) Participant 2 (P2) Thorax angle; f) P2 Knee angle; g) P2 Hip angle; h) P2 Ground reaction force; The shaded area (standard deviation (SD)) demonstrates the fluctuations between loads at 65%, 75%, 85%.

Table 1: P1 and P2 anthropometric measures and self-reported 1RM

PARTICIPANT	GENDER	AGE	BODY MASS (KG)	HEIGHT (CM)	1RM (KG)
PARTICIPANT 1	MALE	27	84	173	135
PARTICIPANT 2	MALE	27	81	174	120

DISCUSSION: As indicated within the results, the trunk angle stayed constant during the first pull, as the knee angle increase at this point was larger than that of the hip. At the point where peak knee extension has been reached, the trunk angle also increased slowly to its peak extension. Peak ground reaction force (GRF) measures were observed during the second pull, when the trunk angle reached the absolute maximum. The increase in load generally led to greater task-demands forced on the trunk region. Trunk angle was greater at 85% of 1RM than at 65% and 75%. In combination, the load-associated increase in joint angles from 65% to 75% and 85% of 1RM links up well with studies that demonstrate higher ground reaction forces (GRF) in response to greater loads (Kawamori et al., 2005). The standard deviation band suggested high variability in performance within the group. Lifters who maintained a steady trunk and hip motion during the first pull and extended the knee joints more rapidly during the second pull, displayed more consistent performance throughout the entire session.

This variability in performance within the group drew attention to the analysis of individual data and highlighted some technical differences between individuals which seemed to be detrimental to their weightlifting performance. Participant 1 (P1) and Participant 2 (P2) anthropometric measures appeared to be similar, although, there was considerable difference between their 1RM (Table 1). The comparison of P1 and P2 data revealed differences in trunk position, knee angle and ground reaction force (GRF). During the first pull P2 demonstrated a more extended trunk position across all loads, resulting in the breakdown of the coordinated knee, hip and trunk movement, a vital element of successful weightlifting (Stone, Pierce, Sands, & Stone, 2006). The interruption of this movement pattern prevented P2 from achieving peak extension at the knee, hip and trunk in the second pull. P2 attempted to compensate the absence of peak extension with a backward lean of the trunk, although, this action caused a delayed catch position and resulted the barbell moving away the body excessively (Rummells, 2016). P1 trunk angle has also displayed slight extension during the first pull across all loads, nevertheless, this change had no effect on the quality of the movement. The aim during weightlifting is to minimise the horizontal deviation of both the barbell and the body and it needs to be monitored and minimised for success (Rummells, 2016). The analysis of P1 and P2 GRF data confirmed the findings of previous studies and underpinned the importance of maximum GRF production during the second pull (Enoka, 1979; Kipp & Giordanelli, 2018). P1`s GRF peaked when maximal force was being applied to the barbell during the second pull and the trunk angle reached maximal extension too. While P2`s previously mentioned movement breakdown and the absence of the coordinated knee, hip and trunk movement resulted in reaching peak GRF measures in the first quarter of the lift, in the first pull instead of the second pull. It is important to reduce the number of errors during weightlifting in order to maximise performance.

CONCLUSION: The results of this study suggest that weightlifting performance is related to several kinetic and kinematic mechanics during the clean. A successful lift depends on the skill of the lifter (Campos, Poletaev, Cuesta, Pablos, & Carratalá, 2006). Therefore, practical research should look to create different coaching systems that would primarily focus on movement literacy by using sub-maximal loads to develop strength and speed characteristics. To learn weightlifting, teaching should start with weights that can be lifted easily with the aim to develop correct motor skills and technical proficiency (Hedrick & Wada, 2008). Training should be addressed from an open perspective to help lifters build an efficient individual technical pattern.

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