

KINETIC AND SEX-BASED ANALYSIS OF THE TRADITIONAL AND HORIZONTAL HANG CLEAN

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The horizontal hang clean (H-HC) is a novel variation of the traditional hang clean (T-HC). This study evaluated the H-HC and T-HC and compared the horizontal and vertical ground reaction forces and the ratio of those forces (H:V), to the horizontal and vertical ground reaction forces and H:V of the countermovement jump (CMJ) and standing sprint start (SSS). Ten men and ten women NCAA Division III athletes performed the T-HC, H-HC, CMJ, and SSS on a force platform. Results revealed that the H-HC produced a significantly ($p \leq 0.001$) greater H:V than the T-HC. There was no interaction between any of these variables and sex ($p > 0.05$). The H-HC should be included in training programs of men and women to increase the likelihood of transfer of training to activities such as sprinting.

Keywords: specificity, sprinting, transfer of training, sagittal plane.

INTRODUCTION: The hang clean is a common weightlifting variation that is often used to train athletes. The kinetics of the hang clean and other weightlifting variations have frequently been evaluated. However, training with the traditional hang clean may be sub-optimal for more horizontally based activities such as sprinting, since specificity is essential for the transfer of training. Therefore, novel variants of the hang clean may be useful.

The kinetic variables of the traditional hang clean have been assessed during a variety of loading conditions (Kawamori, Newton & Nosaka, 2014; Suchomel, Beckham & Wright, 2014). The hang clean has also been compared to exercises such as the hang snatch, along with the analysis of the effect that exercise intensity had on ground reaction forces (GRF) and impulse during these exercises (Jensen & Ebben, 2002). The kinetics associated with the hang clean have also been compared to other exercises such as the jump shrug, high pull, mid-thigh pull, and high power clean (Comfort, Allen & Graham-Smith, 2011). Additionally, some evidence suggests that the hang clean ability is related to athletic performance. For example, hang clean performance is correlated with agility tests and sprint performance (Hori et al., 2008).

The principle of specificity should be followed to increase the likelihood that training exercises optimally improve performance (Randell et al., 2010; Young et al., 2015). Training with exercises offering resistance along with concomitant horizontal displacement of the subject, or subject and added training load, are likely to be most valuable for developing sprinting ability (Rumpf et al., 2016; Young et al., 2015). Plyometric exercises with horizontally directed propulsive force, compared to more vertically oriented options produce horizontal forces that are more similar to sprinting (Duffin, Stockero & Ebben, 2019; Mero & Komi, 1994). Exercises with added external load, such as resisted sprint training compared to non-specific resistance training are also superior for developing sprinting speed (Rumpf et al., 2016).

Studies detailing the GRF during the power clean typically focused on the vertical mechanics (Comfort, Allen & Graham-Smith, 2011; Souza, Shimada & Koontz, 2002), or the horizontal displacement of the barbell during weightlifting variations, but not displacement of the subject (Petrizzo et al., 2016). Resistance training exercises should include the development of horizontal in addition to vertical GRF, in order to maximize the transfer of training (Mero & Komi, 1994; Randell et al., 2010; Young et al., 2015). No study has investigated weightlifting variations focused on maximum horizontal displacement of the subject. None of the weightlifting studies referenced in this article used women as subjects. Thus, little is known about the biomechanics associated with the performance of exercises such as the hang clean for women, or the sex-based differences or similarities. Therefore, the purpose of this study was to introduce the horizontal hang clean (H-HC) and compare its horizontal to vertical ground reaction force ratio (H:V) to that of the traditional hang clean (T-HC). These H:V were

also compared to the H:V associated with jumping and sprinting. This study also assessed sex-based differences therein.

METHODS: Subjects included ten men (mean \pm SD, age = 20.7 ± 1.42 yr; body mass = 82.49 ± 7.96 kg; height = 181.08 ± 9.87 cm) and ten women (mean \pm SD, age = 21.1 ± 2.42 yr; body mass = 65.03 ± 6.32 kg; height = 167.01 ± 7.87 cm), NCAA Division III athletes. Subjects provided written informed consent and filled out a Physical Activity Readiness Questionnaire.

During the research session, subjects performed an activity specific dynamic warm-up and received instruction, demonstration, and practiced the correct technique for the T-HC and the H-HC. The H-HC is similar to the T-HC, except that subjects seek to achieve maximum whole body anterior displacement during the execution of each repetition. Subjects practiced with up to three sets of three repetitions at approximately 50%, 60%, and 70% of their estimated five repetition maximum T-HC load. Subject T-HC loads were determined from their collegiate sports strength and conditioning testing programs. Subjects also practiced the countermovement jump (CMJ) and standing sprint start (SSS) on the force platform, performing five repetitions of each at approximately 50-100% of their maximal ability, with increasing volitional intensity with each repetition. The subjects rested for five minutes.

Subjects were then tested in the following randomized conditions on a force platform including the T-HC, H-HC, SSS, and the CMJ. The T-HC and H-HC test sets were performed with 70% of the subject's five repetition maximum T-HC load, since it is a load that is commonly used, in part since it is known to maximize peak power (Kawamori, et al., 2005). Two sets of one repetition each were performed for all T-HC and H-HC test sets as well as the SSS and CMJ. Three minutes of rest was allowed between each T-HC and H-HC test set. One minute of rest was allowed between the SSS and CMJ test sets.

The peak GRF for each test was obtained from a flush to the floor-mounted force platform (Accupower, Advanced Mechanical Technology, Inc., Watertown, MA, USA). In addition to GRF data, horizontal displacement of the subject during the T-HC and H-HC was determined with a tape measure. Data were analyzed with a statistical software program (SPSS 26.0, International Business Machines Corporation, Armonk, New York) using an ANOVA with repeated measure for exercise type and gender as a between subjects factor. Bonferroni adjusted pairwise comparisons were used to identify specific differences in H:V, horizontal GRF, and vertical GRF between the exercise types. Pearson's correlation coefficients were used to assess the relationship between the H-HC H:V and subject horizontal displacement during H-HC, and the relationship between the kinetic characteristics of the H-HC, T-HC, SSS, and CMJ. The trial-to-trial reliability of each dependent variable was assessed using average measures Intraclass correlation coefficients and analysis of variance for each of the dependent variables. Assumptions for linearity of statistics were tested and met. Statistical power (d) and effect size (η_p^2) are reported and all data are expressed as means \pm SD. The η_p^2 values of .0099, .0588, and .1379 represent small, medium, and large effect sizes (Richardson, 2011). The a priori alpha level was set at $p \leq 0.05$.

RESULTS: Results revealed significant main effects for horizontal GRF ($p \leq 0.001$, $d = 1.00$, $\eta_p^2 = 0.73$), vertical GRF ($p \leq 0.001$, $d = 1.00$, $\eta_p^2 = 0.84$), and H:V ($p \leq 0.001$, $d = 1.00$, $\eta_p^2 = 0.83$). There was no interaction between any of these variables and sex ($p > 0.05$). Figures 1-3 show the horizontal GRF, vertical GRF, and the H:V for each test condition, and the results of the post-hoc analysis. Mean horizontal displacement of the subject for the T-HC and H-HC was 2.33 ± 7.24 cm and 71.05 ± 14.52 CM, respectively, resulting in a 96.7% difference ($p \leq 0.001$) between the hang clean variations. Pearson's correlation coefficients demonstrate that H-HC H:V is correlated with subject horizontal displacement during H-HC ($r = .58$, $p = 0.007$). The H-HC horizontal displacement is correlated SS H:V ratio ($r = .50$, $p = 0.026$). The H-HC vertical GRF was correlated to the SSS vertical GRF ($r = .73$, $p = 0.001$). The H-HC horizontal GRF and vertical GRF are correlated with CMJ horizontal GRF ($r = .66$, $p = 0.022$) and vertical GRF ($r = .53$, $p = 0.017$), respectively. The H-HC vertical GRF is correlated with CMJ vertical GRF ($r = .70$, $p = 0.001$). The T-HC horizontal GRF and vertical GRF were correlated with CMJ horizontal GRF ($r = .48$, $p = 0.031$) and vertical GRF ($r = .58$, $p = 0.008$), respectively.

Interclass correlation coefficients were calculated for all dependent variables, with all values ranging between 0.84 and 0.99 (all p values > 0.05).

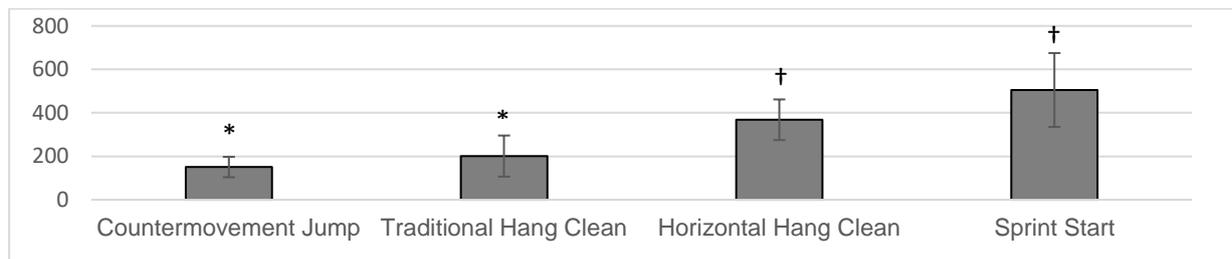


Figure 1. Horizontal GRF (Newtons) \pm SD. * is different ($p \leq 0.05$) than the horizontal hang clean and sprint start. † is different ($p \leq 0.05$) than all other exercise conditions.

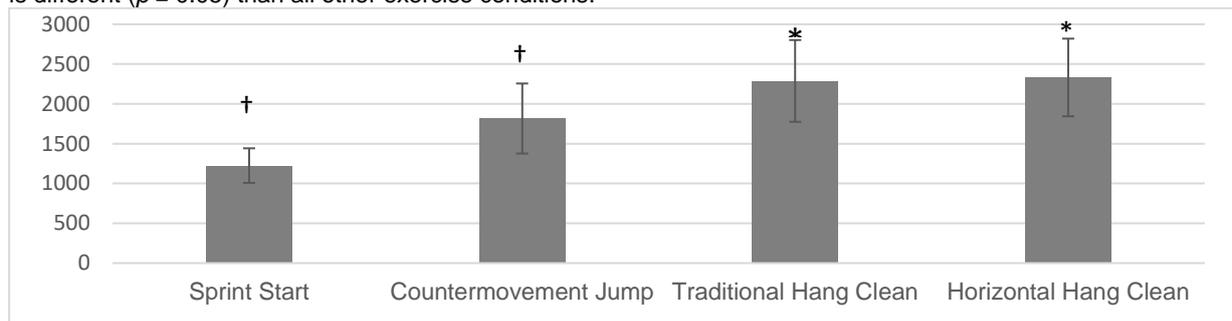


Figure 2. Vertical GRF in (Newtons) \pm SD. * is different ($p \leq 0.05$) than the sprint start and the countermovement jump. † is different ($p \leq 0.05$) than all other exercise conditions.

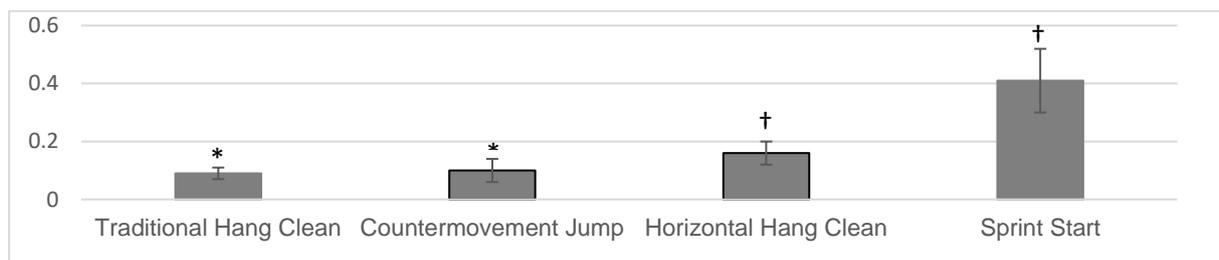


Figure 3. H:V GRF ratio \pm SD. * is different ($p \leq 0.05$) than the horizontal hang clean and the sprint start. † is different ($p \leq 0.05$) than all other exercises.

DISCUSSION: This study introduces the H-HC and is the first to evaluate it compared to the T-HC. Results show that the H:V of the H-HC is significantly greater than that of the T-HC. This finding is important, since reviews on sprint training are replete with information about the relative value of horizontal compared to vertical force, and the necessity of training horizontal force to improve the acceleration phase of sprinting (Randell et al., 2010; Young et al., 2015). Some studies only assessed the vertical GRF associated with the T-HC (Comfort, Allen & Graham-Smith, 2011; Souza, Shimada & Koontz, 2002). However, vertically oriented bilateral exercises have minimal transfer to sprinting performance, whereas whole body horizontally oriented exercises significantly improve sprinting acceleration (Young et al., 2015). In the current study, the H-HC H:V was 0.16:1, compared to research that demonstrated a H:V of 0.22:1 to 0.40:1 associated with a variety of sprint start position (Duffin, Stockero & Ebben, 2019; Mero & Komi, 1994) and horizontally oriented plyometric exercises which demonstrated H:V ranging from 0.20:1 to 0.29:1 (Duffin, Stockero & Ebben, 2019). While not statistically the same as the H:V during the sprinting start, the H-HC produced a H:V that was considerably more sport specific to sprinting than the T-HC.

The current study also demonstrated that subject's horizontal displacement during the H-HC was correlated with their H:V during the H-HC, which was correlated with their SSS H:V.

The H-HC produced greater horizontal GRF and greater mean vertical GRF compared to the T-HC. In fact, the H-HC produced more horizontal GRF than horizontally oriented plyometric exercises such as skipping, bounding, hops and long jumps, and running (Kossow & Ebben,

2018; Mero and Komi, 1994). Thus, compared to the T-HC, the H-HC is a resistance training exercise that increases maximum horizontal force. Training with maximum horizontal force exercises has been recommended for sprinting (Randall et al., 2010; Young et al., 2015).

The T-HC in the current study produced horizontal GRF and a H:V that were statistically similar to the CMJ. Thus, the vertically oriented T-HC is more sport specific to jumping, consistent with the principle of specificity that has been recommended for training for sports (Young et al., 2015).

No sex-based difference were found in this study consistent with previous research assessing the responses of men and women to kinetic variables manifested in the horizontal or vertical dimension for plyometric exercises (Kossow & Ebben, 2018). Future research should investigate the effect of training with the H-HC and its effect on sprinting performance.

CONCLUSION: Practitioners and athletes should use the H-HC as part of their training in order to optimize training in the horizontal dimension. Doing so may increase the transfer of training to horizontal athletic activity such as sprinting. Men and women are likely to respond similarly to this type of training.

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