

**EVIDENCE-DRIVEN APPROACHES TO DEVELOPING SPECIFIC STRENGTH IN
THE FIRST PULL: A NARRATIVE REVIEW.**

¹Shaun A, Joffe. ^{2,3}Chavda, S. ²Sorensen, A. ^{4,5,6}Comfort, P.

¹Faculty of Sport, Technology and Health Sciences, St Mary's University, Twickenham,
London, UK.

²London Sport Institute, Middlesex University, London, UK.

³British Weight Lifting, Leeds, UK.

⁴Centre for Human Movement and Rehabilitation, University of Salford, Greater Manchester,
UK.

⁵School of Medical and Health Sciences, Edith Cowan University, Joondalup, Australia

⁶Institute for Sport, Physical Activity and Leisure, Carnegie School of Sport, Leeds Beckett,
Leeds, UK.

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Address for correspondence: Shaun Joffe. St Mary's University, Waldegrave Road,
Twickenham, TW1 4SX, U.K. Tel: +44 20 8240 4000, E-mail: shaun.joffe@stmarys.ac.uk

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ABSTRACT

To date, a substantial body of literature has focused on weightlifting derivative lifts, primarily emphasizing the second pull phase due to its greater expression of force, rate of force development, velocity, and power output. The biomechanical resemblance of this phase to various athletic movements underscores the relevance of these derivatives in physical preparation across multiple sports. However, while the findings of these studies greatly enhance our understanding of their effectiveness in enhancing neuromuscular qualities, there remains a noticeable gap in the literature regarding the importance of the first pull phase specifically within the sport of weightlifting. The aim of this review was to elucidate the relative importance of the first pull phase in snatch and clean & jerk performance and to explore the selection of specific pull derivative exercises that target the strength development of this phase of the lifts.

Key Words: Weightlifting, Snatch, Clean & Jerk, Exercise Technique, Biomechanics

INTRODUCTION

The outcome of a weightlifting competition depends on attaining the highest cumulative weight successfully lifted during the snatch and clean & jerk (CJ). Each lift is initiated with the "pull" phase where vertical propulsive forces are applied to the barbell to displace it from the floor to a height that allows for a successful catch overhead in the snatch, or front rack in the clean (31,55). The pull phase begins when the weight plates break contact with the floor and continues until the final maximum extension angle of the knee (13,20). The net impulse (force x time) relative to the system mass (body mass + barbell mass) attained from the cumulative propulsive forces generated throughout the pull determine the final velocity of the barbell and, consequently, its vertical displacement during the subsequent turnover phase (5). It follows logically that to enhance the ability to lift heavier loads in the snatch or the clean, the lifter's training program should attempt to augment the capacity for generating a higher net impulse throughout the entire pull phase.

The pull is divided into three sub-phases: the first pull, transition, and second pull (16) (Figure 1). The first pull is commonly defined as from the moment the weight plates break contact with the floor until the first maximum extension angle of the knee (36). Prior to the onset of this phase, the set-up aims to achieve a rigid start position, helping to remove "slack" from within the system, minimizing the electromechanical delay and facilitating an efficient transfer of energy (13). The first pull is characterized by a gradual and sustained application of impulse through the extension of the hip and knee, while maintaining a relatively consistent torso angle to the horizontal line (6,18,22). This action requires large concentric force capacity of the knee and hip extensors, but also a quasi-isometric force capacity of the back extensors to stabilise and maintain the position of the torso. Although the first pull starts from a relatively stationary position, some variation in weightlifters' starting techniques exists, with some incorporating a

dynamic countermovement before initiating the lift. Similar to the countermovement jump, this action may induce a stretch reflex of the knee extensors or allow more time for more cross-bridges to form, thus enabling a greater production of force (47). Nevertheless, the relatively still motion of the barbell at the start, means that one must overcome the barbell's inertia to vertically accelerate it. Consequently, the first pull exhibits a longer duration, (0.45-0.63 s) and lower velocity and power output compared to the subsequent phases of the pull (34,35,37,40,45,59).

The transition phase occurs from the end of the first pull until the maximum flexion angle of the knees (36). Whilst the knees flex throughout this phase, the hips extend simultaneously, aligning the torso in a vertical orientation (13). The re-bend of the knees during the transition frequently results in a temporary lower instantaneous vertical ground reaction force (VGFR), and consequently diminishes the acceleration of the barbell, leading to either a plateau or slight decline in velocity (55,77). It has however, been suggested that a maintenance of acceleration and continued increase in velocity throughout the transition phase is considered optimal and exhibited by more proficient lifters (5). Yet, the ability to achieve this may be influenced by several factors including the tempo of the first pull, the coordinated, simultaneous flexion and extension of the knee and hip joints and the maximal strength capacity of the hip extensor muscle groups (5,29,48).

The second pull is commonly referred to as the "explosive" phase, marked by a rapid and synchronized extension of the hip, knee, and ankle joints (16). This action leads to a rise in impulse through an increase in VGFR within a comparatively short time frame (0.12-0.26 s) (34,35,37,40,45,59). This phase coincides with a second pronounced acceleration of the barbell

and further increase in barbell velocity, subsequently exhibiting the greatest mechanical power output of the lift (6,27,40).

<Figure 1.>

Given the greatest expression of force, rate of force development, velocity and power output occurs during the second pull (20,27,28,59,78), this phase understandably has been a focal point of attention for training by weightlifting coaches when attempting to enhance snatch and C&J performance. This same rationale has also led to the development of the isometric mid-thigh pull (IMTP) test as a measure of strength specific to weightlifting and has been extensively investigated in relation to performance (41,49). The biomechanical similarity of the second pull phase with a range of athletic tasks also largely underpins the applicability and use of weightlifting derivatives in the physical preparation for other sports (16) and has therefore become the subject of extensive research.

Numerous researchers have explored the range of weightlifting derivatives and the impact of varying loads on joint and barbell kinetic and kinematic parameters, the findings of which have been summarised in several review articles (80,81). Furthermore, numerous researchers have also investigated the long-term training effects of these weightlifting derivatives on different facets of athletic performance and have also been summarised in several reviews (10,26,39,68). While this extensive body of work has significantly contributed to our understanding for the utilization of weightlifting derivatives in the development of different neuromuscular qualities, their primary focus lies in enhancing athletic abilities in sports other than weightlifting. Moreover, due to the particular interest in the second pull phase, there is a noticeable lack of

information regarding the relative importance of the first pull phase in the overall improvement of technique and neuromuscular output for weightlifters. Given the net impulse relative to the system mass during the entire pull phase determines the final velocity and displacement of the barbell, it is crucial to devote sufficient attention to training strategies aimed at enhancing the force generating capacity in all phases of the pull.

The aims of this review are threefold: 1) To examine the neuromuscular and biomechanical characteristics of the first pull, providing a scientific foundation for emphasizing the development of this phase to improve weightlifting performance. 2) To review assessment methods for identifying strength deficiencies within the first pull and explore various weightlifting derivative exercises that specifically target the relevant force characteristics of this phase, 3) To identify gaps in the current research literature and offer recommendations for future research, thereby advancing our understanding of the relative importance of the first pull and how to develop it.

THE IMPORTANCE OF MAXIMAL FORCE CAPACITY IN THE FIRST PULL.

The first pull is an integral phase within the snatch and clean, as the correct technical execution serves to enhance the overall efficiency of the lift (22,36). The optimal coordinated motion of joints, body segments, and the barbell are crucial in reducing excessive external joint torque while simultaneously preserving the balance between the centre of mass (COM) and the base of support (BOS) (13,57). This enables a smoother transition phase and a more optimal position for the application of VGRF during the second pull (5,20). However, it is important to consider that the capacity to express force within the first pull is also a key determining factor of performance. Peak VGRF during the first pull has a nearly perfect ($r > 0.90$) relationship with the load lifted in the snatch and clean (6,52,77,78). Furthermore, elite weightlifters have been

shown to produce greater peak VGRF relative to the system mass during the first pull in the snatch and clean compared with district level weightlifters (43,52). Despite the strong relationship between force production in the first pull and load lifted, the capacity to express force during this phase of the pull is considerably lower compared to the later phases (9,51,77). This is likely attributed to the pull phase of the snatch and clean exhibiting an ascending strength curve, wherein the maximal force generating capacity increases throughout most of the ascending concentric range of the movement (9,50,65,79).

Joffe et al. (50) reported that the peak force (PF) generated during the isometric pull from the start position (IPSP) of the clean was substantially lower compared to the IMTP among male and female national and international level weightlifters (IPSP 1443 ± 425 N, IMTP 2640 ± 767 N, ES = 2.45) (Figure 2). The lower force capacity in this phase is likely attributed to the mechanical disadvantage and an increased moment arm, particularly of the knee when in a triple-flexed (ankle, knee, and hip) position (14,17,24). Additionally, the relatively long muscle-lengths of the hip and knee extensors in this position, likely exceed the optimal range for force production, thus limiting the capacity to express force in the earlier portion of the lift (74). Similar ascending strength curve characteristics have been described in other lower-body multi-joint strength exercises with reasonable biomechanical similarity to the first pull, namely the back squat (7) and deadlift (4,8).

<Figure 2.>

It is rational to suggest that the maximum weight that can be lifted throughout the entire range of motion (ROM) of an exercise is primarily limited by the force-generating capacity of the weakest mechanical position. Several researchers have demonstrated higher correlations

between isometric PF assessed during the initial, weaker range of the concentric phase of an exercise, and the corresponding exercise 1RM (back squat and deadlift), in comparison to isometric PF measured during the latter, stronger range of the movement (4,7). This phenomenon is present, not only in lower-body strength exercises, but also in the weightlifting movements. Joffe et al. (50) and Ben-Zeev et al. (9) each demonstrated that isometric PF in the IPSP exhibited stronger correlations with weightlifting total in male and female national and international level weightlifters compared with the IMTP ($r = 0.95$ vs. $r = 0.86-0.88$). These findings indicate that the maximum force capacity in the first pull may be a more crucial factor for performance than in the subsequent second pull. Thus, the development of specific strength relating to the first pull phase should be a key consideration in designing a weightlifter's training program. However, it is essential to consider supplementary evidence obtained from biomechanical analysis of the lifts themselves to further verify this supposition.

As alluded to previously, the final velocity of the barbell at the end of the second pull determines its vertical displacement in the subsequent turnover phase (5). However, it is important to acknowledge that this final velocity corresponds to the total relative net impulse generated across all sub-phases of the pull (75). Interestingly, several researchers have reported between 56-75% of the final velocity is attained at the end of the first pull during the snatch (34–36,75). This illustrates the substantial contribution of the impulse applied in the first pull to the final velocity in the second pull. In support of this Sorensen et al. (77), reported larger correlations between the mean resultant force in the first pull and barbell load set at 90% of the clean 1RM, compared with the mean resultant force in the second pull ($r = 0.98$ vs. $r = 0.91$), further exemplifying the importance of force production in this phase.

Numerous investigators have also explored the impact of incremental loads, ranging from 70% to 100% of the 1RM in the snatch (40,75) and clean (2), on barbell kinematics during each sub-phase of the pull. Interestingly, the result of these studies collectively demonstrates that with increasing load, the first pull experiences a more pronounced increase in duration and decrease in velocity of the barbell compared to the transition and second pull (figure 3). Moreover, when contrasting the force-time profiles of the snatch and clean during maximum attempts in competition, greater VGRF were apparent during the clean first pull and transition, with no differences observed in the second pull between the lifts (54). The larger forces generated during the first pull of the clean was attributed to the heavier weights lifted, resulting in greater barbell inertia at the onset of the lift. Collectively, these findings illustrate a greater diminished ability to accelerate the barbell when subjected to heavier loads during the first pull compared with the latter phases. This indicates that the first pull phase being the weakest, is therefore a key limiting factor to the load lifted in the snatch and clean.

<Figure 3.>

Weightlifting coaches frequently characterize the first pull phase as "slow", "controlled" and a "more technical" portion of the lift (18,21,22). It has been proposed that executing the first pull too quickly may impede the barbell acceleration and velocity in the transition phase. This is attributed to its adverse impact on the positioning of the barbell's COM in relation to the BOS, often resulting in a forward movement of the bar and subsequently the lifters body (36). This forward shift also amplifies the external joint moments around the hip and lower back, therefore undermining the efficient application and transmission of VGRF. Moreover, the observed reduction in velocity during the transition that follows the first pull may be attributed to the need for a precise rearrangement of the knee joints, a task that becomes challenging at higher

217 velocities. Nevertheless, this decrease in velocity subsequently requires greater energy to re-
218 accelerate the barbell during the second pull and is considered a less efficient movement
219 strategy (5). However, it is important to note that there is a scarcity of experimental research
220 available to corroborate this.

221
222 Certainly, when teaching the lifts to beginners, it is both logical and commonly recommended
223 to emphasize a deliberately slow first pull (18,22). This approach ensures precise technical
224 execution and maintains the proper tempo of the movement, enabling the subsequent phases to
225 be performed correctly. However, with increasing technical competence and therefore greater
226 load, plausibly, the emphasis shifts toward moving the barbell with greater intent during the
227 first pull. This has been partly verified, given that elite weightlifters produce greater peak
228 VGRF relative to the system mass during the first pull in the snatch and clean compared with
229 district level weightlifters (43,52), with relative force determining acceleration. It is reasonable
230 to anticipate that lifters who possess strong technical proficiency will express near maximal
231 intent to move the barbell quickly from the floor and throughout the pull during heavy maximal
232 attempts in the snatch or clean. The comparably lower velocity exhibited in the first pull than
233 the latter phases is likely a product of the inertia of the heavy barbell and the weaker mechanical
234 position, rather than it be a purposefully slow movement. Consistent with previous
235 interpretations, given the lower velocity, and relative importance of maximal force production,
236 the first pull can be considered a more ‘strength-oriented’ phase of the lift (30). Therefore,
237 prioritizing the improvement of maximum strength during the first pull appears to be a critical
238 component of a weightlifter's training program.

METHODS FOR ASSESSING A DEFICIT IN FIRST PULL STRENGTH CAPACITY

It is incumbent upon the weightlifting coach to determine whether a deficiency in first pull maximal force capabilities exist, to determine if it warrants significant training focus. Though no universal method exists, recent studies provide insights to help make such determinations. As previously noted, ‘nearly perfect’ relationships were found between the IPSP PF and successful performance in the snatch and C&J ($r = 0.94$ and 0.95 , respectively) (50). These findings provide valuable insights that can be applied to determine the ‘optimal’ range of PF for IPSP necessary to achieve a target load in the snatch and C&J. Linear regression equations based on these data (Table 1) can be utilized to assist in determining the force requirements for the IPSP based on a specific performance target load in either lift. Based on the data reported by Joffe et al. (50), an illustrative model for the snatch is presented, focusing on a target of 100 kg. The model is expressed as follows:

$$\text{IPSP (PF)} = (100\text{kg} \times 13.229) + 227.52$$

In the equation, IPSP (PF) is the peak force for the isometric pull from start position. '100 kg' is the target load for the snatch lift. The slope, 13.229, shows the relationship between the target load and IPSP PF. The y-intercept, 227.52, represents the baseline IPSP value without added load. The results of this equation suggests that the expected IPSP net force for a target snatch with a load of 100 kg is 1550 N, with 95% confidence intervals for this estimate spanning from 1328 to 1773 N. The considerable variability within this range may be attributed to the diverse weight categories and technical abilities among the participants observed in this study (50). Therefore, a reasonable strategy for coaches and lifters would be to target between the predicted load and the upper confidence interval. The authors of this study also noted the ratio of PF between the IPSP and IMTP as $55.6 \pm 9.3\%$, although a more recent study reported this as

between 65 to 67% (9). Enhancing understanding of whether an optimal ratio exists between the isometric PF in these positions of the pull could reveal strength deficits within specific phases of the movement and therefore inform decisions on prioritizing training focus on a particular phase. It is important to consider however, that this method relies on coaches having access to equipment like force platforms, an isometric rig and suitable analysis software or scripts. Nevertheless, alternative options are available that are less reliant on such equipment.

< Table 1. >

One alternative to assess the maximum pulling strength from the floor is by measuring the deadlift 1RM. However, Zecchin et al. (91) examined the correlation between deadlift 1RM with snatch and C&J, and reported non-significant, yet moderate correlations ($r = 0.58$, $p = 0.37$ and $r = 0.53$, $p = 0.59$). The lack of statistical significance may be explained due to the multiple correlations examined in the study and its relatively small sample size. The description of the deadlift protocol within the study also lacks clarity regarding whether the exercise adhered to the technique of the pull phase of the snatch and clean, or more that of a powerlifting-style conventional deadlift, which have distinctly different technical features (3,18). Therefore, to accurately evaluate the maximal dynamic strength of the pull as it relates to weightlifting, coaches may consider implementing an assessment of snatch and clean deadlift 1RM. These pull variations incorporate the specific grip and technical requirements of each lift to ensure they accurately reflect each phase of the pull. To the best of the authors' knowledge, no researchers have investigated the snatch and clean deadlift pull derivatives in relation to weightlifting performance.

A common criticism of employing regression models or comparable predictive techniques, which provide outcomes tailored to the examined population, lies in their diminished predictive efficacy when extended to dissimilar populations, particularly in cases of elite athlete (89). Consequently, more individualised methodologies that rely less on these sorts of projections may be more appropriate for this population. Sandau and Granacher (75) investigated not only the load-velocity profiles among a cohort of elite weightlifters during the snatch lift, but also a deliberate examination of individual profiles. The primary objective was to assess how barbell loads between 70-100% of the snatch influenced acceleration capabilities by examining the load-velocity regression slope for the first pull, transition and second pull phases. As discussed previously, the group analysis unveiled a more pronounced decline in the load-velocity slope during the first pull compared with the subsequent phases. However, the researchers also observed that certain individuals displaying greater acceleration declines in phases other than the first pull. This indicates the necessity for an individualised assessments approach to evaluating strength characteristics within the pull. Based on their findings, the authors proposed that this data could be utilized to inform exercise selection to target the sub-phase with the most pronounced negative load-velocity. Cost-effective options like mobile apps, video analysis software, and velocity measurement devices enable reliable barbell velocity measurement, broadening the method's potential use in practice. However, importantly, this relies on video capture availability to enable a valid identification of the first pull by knee joint angle (13). Overall, further research is warranted to determine valid and reliable methods for evaluating force capacity within the first pull.

A RATIONALE FOR FIRST PULL-SPECIFIC TRAINING

A range of authors have discussed the technical considerations and methods for teaching the first pull (13,18,22), however there is limited information regarding training strategies for

developing the position-specific strength required for this phase. The first pull phase is initiated from a flexed hip, knee, and ankle position, therefore several of the primary extensor muscles of these joints, are positioned at relatively long muscle-lengths compared to the subsequent phases of the lift (74). With this in mind, the body of research on ROM and muscle-length-specific strength training may provide valuable insights that inform particular training strategies for the targeted development of each phase of the pull. For optimal neuromuscular adaptations, it is generally recommended to engage in full ROM strength training as this ensures the activation of a greater number of muscle fibres, stimulating the greatest volume of muscle for adaptation (23,60,76). However, there are evidently unique adaptations associated with strength training with full and partial ROM that have potentially important implications for training the pull in the snatch and clean.

The authors of several related studies (11,46,61,71,73,90) investigating full versus partial ROM strength training in the squat have reported very similar outcomes, showing that full ROM squat training leads to larger increments in 1RM within the trained exercise (16 to 32%). This is accompanied by frequently comparable improvements in partial ROM squat 1RM (0 to 24%) performed within the latter region of the ascent phase (i.e., quarter squats). In contrast, when performing strength training with partial ROM squats (i.e., half or quarter squats), often similar magnitudes in 1RM are observed in the trained exercise (7 to 36%), however, these adaptations appear to be highly specific to the trained partial ROM and have negative to small changes in 1RM strength in the full ROM squat (-5 to 11%). Similar findings have been reported for lower- and upper-body, multi- and single-joint dynamic and isometric strength training studies comparing strength training across different ranges of motion and muscle-lengths (38,64,69,72). The results of these studies collectively demonstrate a more pronounced transfer

of strength improvements from strength training at long muscle-lengths to short muscle-lengths, contrasting with the limited transfer in the opposite direction.

Although this has not been directly examined in the context of the weightlifting pull, the combined outcomes of these studies carry several important implications for enhancing force capacity during the different phases of the pull. Firstly, the muscle-length specific adaptations support the existing strategies for optimizing force generation capabilities for the second pull using the series of pull derivatives as discussed in several previous reviews (80,81). Nevertheless, these collective findings distinctly indicate that strength training at shorter muscle-lengths, as seen in second pull-focused derivatives, yields limited benefits for enhancing strength at long muscle-lengths, as evident in the first pull. Consequently, this underpins the necessity for training the first pull using a set of specific derivative exercises tailored to replicate the precise joint angles and muscle-lengths encountered in this phase. By deliberately overloading the specific positions relevant to the first pull, it becomes feasible to induce specific increments in strength through targeted hypertrophy in the hip and knee extensors and specific muscle activation patterns. This subsequently should increase the capacity for force production during the first pull and will likely increase the ability to generate greater total impulse throughout the entire pulling phase.

STRATEGIES TO DEVELOP MAXIMAL STRENGTH IN THE FIRST PULL.

The authors of several review articles have summarised the literature on the breadth of weightlifting pulling derivative exercises which emphasize the overload of the second pull (80,81), with multiple researchers having further added to this area since (15,53,56,58,67,82–88). However, the literature dedicated to derivatives focused on the first pull are scarce, with only a single exercise technique review published in the last 15 years (19). This section outlines

the specific weightlifting derivatives which target strength development of this phase informed by both the available literature and the practical insights of the authors. it is important to highlight that for optimal efficacy, the utilization of pulling straps is recommended for the majority of these exercises as this mitigates the potential adverse impact of grip strength limiting the expression of maximal force through the lower body.

Snatch and Clean Pull

The snatch and clean pull are staple assistance exercises that play a central role in a weightlifter's training program, and the technique has been extensively discussed in several review articles (18,81). This exercise encompasses all three sub-phases of the pull and is performed with a similar intent to vertically project barbell at the end of the movement. Whilst the biomechanical characteristics of hang and mid-thigh pull variations have been extensively explored (16), fewer biomechanical studies have investigated the complete pull from the floor (42–44). Häkkinen & Kauhanen (43) reported that when elite weightlifters performed snatch or clean pulls from the floor with the corresponding snatch or clean 1RM, lower PF values in the first pull phase were observed, compared to the competition lifts at equivalent loads. This difference is likely attributed to a diminished sense of 'intent' during the snatch and clean pulls. Such lack of intent to accelerate the bar, may compromise the overload stimulus, particularly in the first pull. However, a crucial benefit of using clean and snatch pulls over the snatch and clean, is that the removal of the catch phase enables these pull derivatives to be performed with loads surpassing the 1RM of the competition lifts, allowing a greater force overload in the pull (16). Considering the ascending strength curve present in the pull, snatch and clean pulls performed with heavier loads likely induce a greater force overload during the first pull phase compared with the later phases of the lift. However, since the movement should be executed with near maximal intent from start to finish, the second pull is overloaded in a more ballistic

manner, allowing the complete pull to be trained. Determining the 1RM for these exercises with the intention of prescribing intensity for training is however challenging, due to the complexities in quantifying a complete pull. Instead, these lifts are often prescribed based on the 1RM of their respective competition lift, typically, between 90-120% of the 1RM (1,21,25,32,42,43,66). However, additional research is needed to investigate the optimal method for prescribing load for these pull derivatives.

Snatch and Clean Deadlift

The snatch and clean deadlift are additional pull derivative exercises commonly used by weightlifters. Although there is little or no reference to these derivatives in the academic literature, they are frequently discussed in popular weightlifting coaching texts (1,12,21,32). It is crucial to differentiate these lifts from the snatch and clean pull, and from the conventional deadlift. While these pull derivatives should maintain the same relative joint positions and movements as in the snatch and clean pulls, they eliminate the intention to vertically project the barbell with an aggressive shrug and drive onto the balls of the feet at the end of the pull. Due to this, theoretically, greater loads can be lifted compared with the classic pull variations. Consequently, these exercises are performed with lower velocity and less pronounced accelerations throughout the movement. Additionally, the lowering phase of the lift can be incorporated and executed with control to emphasize the same positions as the ascent, thereby enhancing positional strength in the pull. The reduced emphasis on strict rhythm and tempo in these lifts, combined with their capacity to accommodate heavier loads, indicates that these derivatives are most conducive to training phases aimed at maximizing strength development. Determining the 1RM from these exercises is practical and aids in prescribing intensity for training and evaluating maximal strength capabilities. However, to date, there are no studies examining these derivative 1RMs in relation to weightlifting performance, leaving a gap in

guidance for appropriate load prescription. While some research has explored heavier loaded pulls exceeding 120% of the respective competition lift 1RM (25,66), it has been suggested that these loads can alter joint and barbell kinetics and kinematics, compromising their specificity to the competition lifts. Nevertheless, there remains a significant gap in understanding the maximum strength capacity in deadlift variations compared to the competition lift, which limits our ability to prescribe suitable loads for these pull derivatives. Considering the guidance that snatch and clean pulls can be performed with loads up to 120% of their corresponding competition lift 1RM, a conservative recommendation would be that these lifts can be performed with loads between 120-140%. However, given the lack of empirical research into these assistance exercises, further research is required to better understand the optimal loads to be used for the snatch and clean deadlift for developing maximal strength in the pull.

Pull to the Knee

The pull to the knee involves isolating the first pull from the rest of the pull phase (13,18,22) (Figure 4). This as a standalone exercise is largely considered a remedial tool to help improve the technical aspects for the first pull, however, this derivative can also help to overload the key musculature involved in this phase. The first pull relies largely on producing large concentric knee extensor torque while resisting external joint torque around hip and lower back. The isolation of this exercise to a partial ROM in the initial portion of the pull, enables a more concentrated overload, effectively isolating and addressing the weakest mechanical position of the pull. The prescription of load for this exercise would likely vary between the 1RM of the competition lift and 1RM of the respective deadlift. When executing this derivative, it is crucial to ensure the barbell follows the correct trajectory, moving horizontally toward the lifter throughout the pull. Simultaneously, it is essential to maintain the barbell's COM within the

BOS allowing for a slight rearward shift in the centre of pressure in the feet (33). The velocity and intent with which the exercise is performed is determined by the weight of the barbell. When dealing with lighter loads, prioritizing a controlled execution is necessary, while heavier loads should be approached with the goal of moving with intent, all while maintaining proper lifting technique. Additionally, this derivative can be modified further by incorporating pauses at various points during the lift to emphasize the overload on specific positions. For instance, a lifter might choose to pause at the apex of the first pull, thereby enhancing the ability to sustain this position.

<Figure 4.>

Snatch and Clean Isometric Pull.

To further enhance the production of first pull force capabilities, incorporating isometric strength training into this phase of the lift can be highly effective. Isometric strength training has been extensively studied and proven to be a valuable training modality for maximizing strength gains. It demonstrates a remarkable specificity to the trained position with positive transfer to dynamic athletic performances (63). Notably, similar to our previous discussions, isometric training performed at longer muscle-lengths has been found to elicit more pronounced systemic changes in strength across the entire length-tension curve, compared with short muscle-lengths (69). Therefore, this training method holds promise for effectively increasing force capacity within a biomechanically disadvantaged position, making it particularly well-suited for developing maximal force capacity during the first pull in the snatch and clean. To target the first pull phase specifically, variations can be introduced by adjusting the barbell height at different points during the first pull to challenge force production at varying positions throughout this phase. Isometric training can be implemented in various

ways. One approach is to utilize an isometric rig, similar to the apparatus used for assessing IMTP. Alternatively, modifications can be made to a secure lifting rack to accommodate these exercises, or they can even be performed with supramaximal loads to ensure the barbell cannot be separated from the start point. Although isometric strength training is of increasing interest in the field of strength and conditioning, there remains an absence of research investigating this training method in relation to weightlifting performance.

Pull derivatives from a Deficit.

Each of the pull variations described above can be progressed further by performing them from a deficit. This involves completing the pull while standing on an elevated platform, thereby accentuating the ROM over which the pull is performed (Figure 5). Subsequently, this increases the mechanical disadvantage and the muscle-lengths of the hip, knee, and ankle extensors at the start of the movement. Deficit pulls can be executed at various platform heights, but it is advisable to utilize platforms ranging from 1-10 cm in height. This ensures that the feet have sufficient space within the ~21 cm gap between the barbell and the floor. The use of a deficit with pull derivatives has been discussed in some popular coaching texts (1,21), but has not been examined in the academic literature. The deadlift from a deficit has however, been briefly discussed in an exercise technique review (62), suggesting this strategy may lead to ROM specific strength gains, that are not stimulated in the standard lift. Further increasing muscle-length by introducing a deficit, may also further increase the stimulus for hypertrophy (70), particularly for the deadlift variations where a controlled eccentric phase is performed. Furthermore, the evidence suggests that by increasing the force capacity within this deficit ROM, will likely translate to the increased force capacity at shorter muscle-lengths (72), therefore improvements in strength are likely to be translated to the latter phases of the pull. To implement a deficit while performing one of these pull derivatives, it's essential to employ the

right equipment. Specialized pulling blocks or flat weightlifting weight plates can serve this purpose. However, coaches must ensure that these tools can endure both the barbell and lifters weight, have an adequate width to accommodate the proper pulling stance, and remain stable on the surface where they are positioned. A crucial factor to consider is the need for adequate mobility when incorporating deficit variations in order to maintain the key positions. It is advisable to gradually increase the deficit from smaller to larger ranges over time based upon the lifter's competence. Furthermore, it's worth noting that the force capacity diminishes along the ascending strength curve, and thus, training loads should be adjusted accordingly.

<Figure 5.>

Implications for Periodization.

These exercises necessitate thoughtful consideration of how they are integrated within the periodized cycle. The principal goal of these derivatives is to enhance the lifter's ability to generate maximum force and secondly reinforce the correct technique in the first pull. These exercises are executed at comparably slower velocities when contrasted with the competition lifts and other derivatives. Furthermore, these derivatives predominantly emphasize overload of the hip and knee extensors at extended muscle-lengths, and are performed with relatively heavy loads, which makes them well-suited for training periods focused strength and hypertrophy development (11,69,70,73). Considering that a weightlifter's essential physical qualities are relatively few, and have significant time between competitions within a given year, a traditional 'block' periodization model may be most appropriate, where a singular or a few complementary physical qualities within designated blocks of training. The derivative lifts targeting the first pull may be particularly effective for training blocks aimed at maximizing strength and hypertrophy development, especially during the early stages of the competition

cycle. Conversely, derivatives aimed at refining technique and overloading during the second pull phase may be better suited closer to competition. Providing ample time prior to the target competition allows for the development of these qualities, while also allowing for dedicated periods of competition-specific training.

<Table 2.>

RECOMMENDATIONS FOR FUTURE RESEARCH

While a significant body of peer-reviewed literature focuses on weightlifting, there remains a notable gap concerning the biomechanical and neuromuscular characteristics of the first pull in the snatch and clean. Although biomechanical studies provide valuable insights into the kinetic and kinematic properties of this phase, a scarcity of research exists on assessing maximal force production during this critical stage, thereby impeding the comprehension of precise strength deficiencies and their implications for training and performance. Furthermore, a notable insufficiency exists regarding distinct weightlifting pull derivatives designed to primarily enhance the first pull. Much of the scholarly focus in this realm has been directed towards derivatives that emphasize training for the second pull. This discrepancy underscores a pressing need for research into first pull specific weightlifting pull derivatives.

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Figure 1. Key positions, phases and sub-phases of the snatch and clean lift. (A) Snatch, (B) Clean.

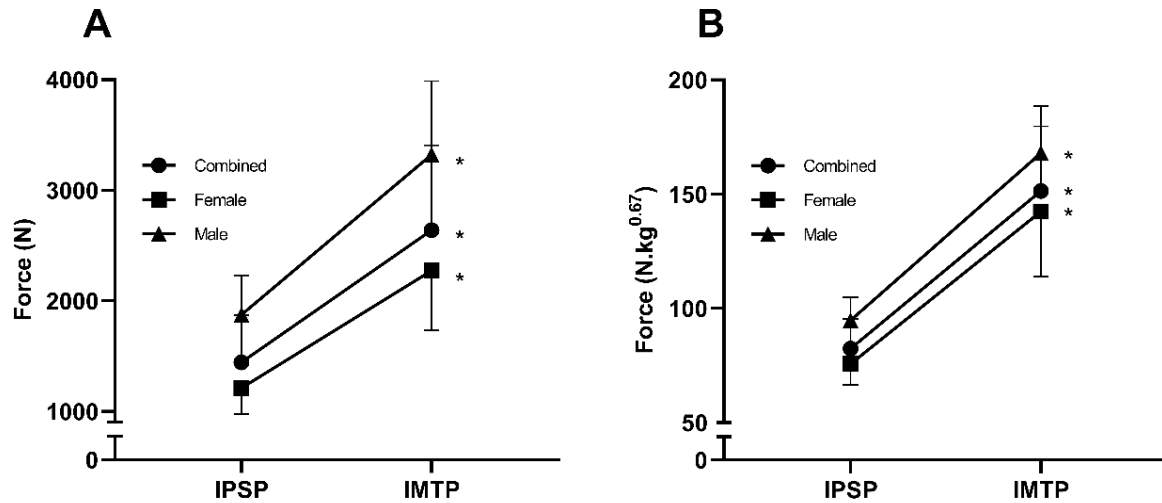


Figure 2. Absolute (A) and allometrically scaled (B) difference between IPSP and IMTP for male, female and combined male and female groups. IPSP = Isometric Pull from Start Position, IMTP = Isometric Mid-Thigh Pull. * Denotes statistically significant difference between IPSP and IMTP at $p < 0.001$. Obtained with permission from Joffe et al. (50).

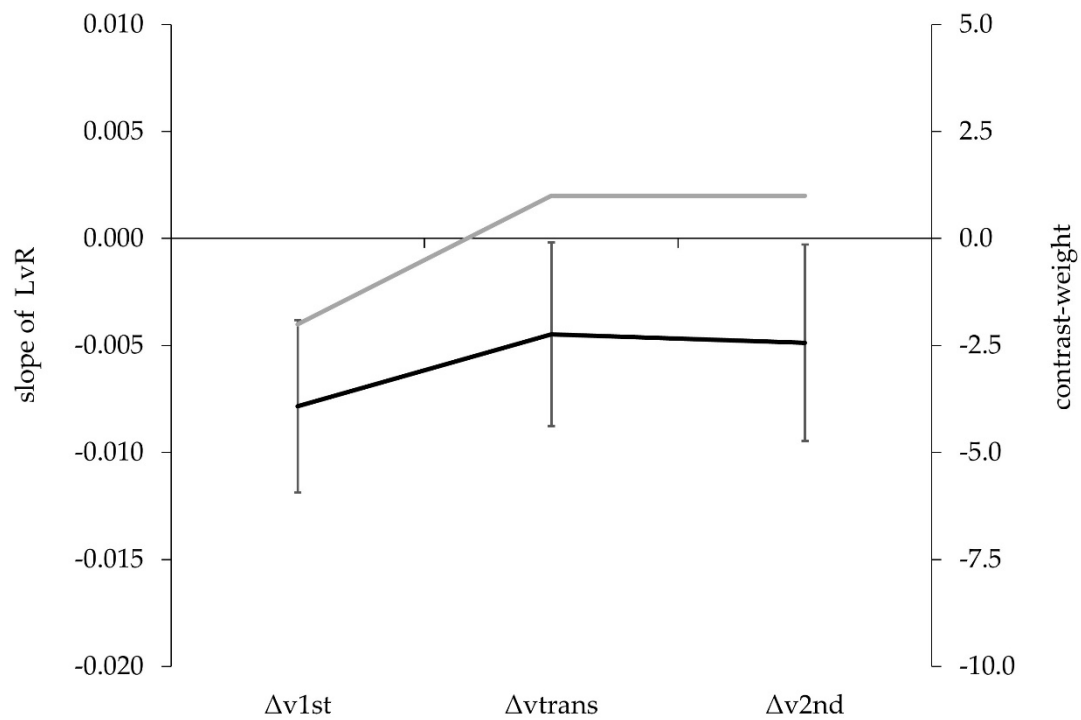


Figure 3. Group data (mean $\pm$ SD) illustrating the slope of the load-velocity relationship in the sub-phases of the pull phase in the snatch (black) and a priori contrast-weights of the study hypothesis (grey). Obtained with permission from Sandau & Granacher (75).



Figure 4. Snatch pull to the knee.



Figure 5. Clean pull performed with a 5cm deficit.

Table 1. Linear regression equations to predict IPSP peak force from snatch and clean & jerk

Lift	R ²	<i>P</i>	β	Slope	95 % CI
Snatch	0.89	<0.001	227.52	13.229	222.4
Clean & Jerk	0.89	<0.001	163.139	11.219	227.7

875 **Table 2.** First pull derivative exercise programming guidelines.

Derivative Exercise	Intensity	Prescription variables
Snatch and Clean Pull	90-120% of Snatch / Clean 1RM	1-5 reps, 3-6 sets
Snatch and Clean Deadlift	70-100% of Snatch / Clean Deadlift 1RM or 100-140% of Snatch / Clean 1RM	1-5 reps, 3-6 sets
Snatch and Clean Pull to Knee	70-100% of Snatch / Clean Deadlift 1RM or 100-140% of Snatch / Clean 1RM	1-5 reps, 3-6 sets, 0-3 s pause at knee
Isometric Pulls	80-100% MVC	1-5 s per rep, 30-90 s total time per session
Pulls from Deficit	Dynamic: 70-90% of the derivative exercise 1RM Isometric: 80-100% MVC	1-10 cm deficit Dynamic: 1-5 reps, 3-6 sets Isometric: 1-5 s per rep, 30- 90 s total time per session