Comparison of the Effect of Heavy Pulls vs Light Powers on a Subsequent Clean in Trained Athletes

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by

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ABSTRACT

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The sport of weightlifting has been competed since the first modern Olympiad. Competition in weightlifting consists of 3 attempts the snatch and clean and jerk declared by the athlete and their coach prior to the starting of the lift. While waiting for the athlete's lift, waiting periods can change and warm up attempts may need to be adjusted. Often, coaches prescribe either a complete "light power" or partial "heavy pull" repetition of the competed movement during a long wait. Previous literature indicates that a heavier stimulus may cause a "post-activation potentiation", or "post-activation performance enhancement" effect on the subsequent lift. However, some evidence indicates that a heavy pull closely preceding a subsequent clean may disrupt technique. Despite the common practice to perform a heavy pull or lighter power clean or snatch in the warmup area, little information is known about whether this movement will potentiate the following repetition or disrupt technique. The purpose of this investigation was to investigate the potentiation and technique effects of the heavy pull and light power on a subsequent clean. Methods: The subjects (males n = 9; females n= 2) were eleven well-trained athletes (weightlifting, track and field, crossfit) in the clean. After warmup, a series of cleans were performed leading to a 90 % 1 RM clean followed by a 75% power clean or 112% clean pull (order randomly assigned), this was followed by a 90% clean. Kinematics were measured using Qualisys M3 motion capture. Subjective effort was measured after each 90% clean using rating of perceived exertion (RPE). Results: Men were stronger than women how ever there was no

difference in the outcome. Peak bar velocity was not statistically different pre-post ($p \geq 0.5$). Vertical displacement was not statistically different pre-post ($p \geq 0.5$). Horizontal displacement was not statistically different ($p \geq 0.5$). Catch phase duration was not statistically different ($p \leq 0.5$), however effect size indicates small to moderate decreases in duration in both conditions. Stronger athletes *appeared* to have less technical disruption compared to lesser lifters. Following the power clean there was a statistically significant reduction in RPE ($p \leq 0.5$, cohen's $d=0.595$ 95%CI=0.171 to 1.02).

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Chapter 1. Introduction

Competition in the Sport of weightlifting has occurred since the first modern Olympiad in 1896. Although many changes in the competition format have taken place since 1896, currently weightlifting consists of three attempts for the snatch and 3 attempts for the clean & jerk movements, the competitor with the heaviest total of their two best lifts wins the competition.

The clean & jerk is nearly always the greatest contributor to the total of the athlete and the clean and the jerk are often used as a whole lift or in parts for strength and conditioning among many different strength-power athletes. (Comfort et al., 2022; *Weightlifting - News, Athletes, Highlights & More*, n.d.) As lifts in the clean can go over 200 kilograms (440lbs), the preparation of the athlete in the training hall leading up to, and in between their three attempts on the competition platform can impact the result of the competition and success of failure of the competed lifts (Stone & O'Bryant 1987). In competition, the authors have observed both the use of heavy pulling movements with no catch phase and light power movements that are caught above 90 degrees of knee flexion in between long waiting periods, as well as prior to the first attempt of both the snatch and clean and jerk.

Evidence indicates that pulling movements can be used to build strength, RFD and power for the enhancement of weightlifting movements (Comfort et al., 2022; Harbili & Alptekin 2014; Stone & O'Bryant 1987; Suchomel et al., 2015). Indeed, the use of heavy pulls from a variety of positions (i.e. floor, knee, power position, etc.) have long been used for both weightlifters and for the enhancement of performance by other athletes (Stone & O'Bryant 1987; Suchomel et al., 2015). Heavier loads (>120%) lifted from a variety of positions are recommended during periods of maximum strength training (Roman 1986; Frolov et al., 1983; Medvedev et al., 1981; Sandau & Granacher 2020; Suchomel et al., 2015). However, Frolov (1983) and Häkkinen and Kauhanen (1986) report that timing and kinematic characteristics, such as acceleration, velocity, and displacement, during the pulling motion from the floor can differ from the pull during competitive lifts. This became apparent as the load on the barbell exceeds 110% of 1RM. Above 120% of 1 RM these differences can be substantial (Frolov 1983).

Based on these observations (Frolov et al., 1983), it has been recommended that pulling performed from the floor, shortly before weightlifting competitions, should include loads of no more than ≈ 90-110% of maximum, as heavier loads may disrupt transference due to temporal, spatial and kinematic differences (Medvedev 1986; Medvedev 1982, Medvedev et al., 1983; Medvedev et al., 1981; Roman 1986; Frolov et al., 1983).

Considering the possibility that heavy pulls from the floor might disrupt the temporal characteristics of weightlifting competitive movements (snatch and clean), weightlifting coaches must consider that performing pulls from the floor with loads >110% interfere with the complete weightlifting movements (snatch and clean & Jerk). However, there are several reasons to question this possibility:

First is observation: we have observed elite weightlifters performing pulls from the floor with loads > 110% as late as 1-3 days before competition, including at the world championships and the Olympics. Furthermore, the authors have observed lifters performing heavy pulls during long waits during national and international level competition, often with only minutes between attempts.

Second, although, heavy pulling movements from the floor have been shown to have different temporal characteristics (Frolov et al., 1983; Häkkinen & Kauhanen 1986), no evidence has been presented that these movements actually will disrupt the execution of subsequent weightlifting movements (snatch and clean & jerk).

Third, it is possible that performance of heavy pulls may act to potentiate force and velocity during a subsequent lift. (Tillin 2009) While, heavier pulling movements have been shown to potentiate subsequent lighter pulling movements (Stone et al., 2008), it is not known whether a heavier pulling movement will potentiate a subsequent snatch or clean.

Additionally, observation by the authors indicate that some weightlifting coaches often choose to prescribe a light power clean during long wait times, or before first attempts on the weightlifting platform. The heavy pull may potentiate the attempt (Stone et al., 2008). A light clean (power clean) at a high power output, before the attempt may also cause a potentiating effect (Suchomel et al., 2016). It is also possible that the reduced work involved by removing the front squat portion of the clean by limiting the range of motion (power clean) may allow the lifter to experience/feel less fatigued going into their attempt. Additionally, in the clean and jerk movement, performing a lighter power clean allows the coach to prescribe a jerk following the clean, unlike the heavy pull. However, it is also possible that, if the power clean is too light the timing and kinetic characteristics may create and interfering after effect. The effect of a potentiating light power clean upon a full clean has not been investigated. Indeed, few researchers have investigated the kinetics and kinematic of a power clean (Comfort et al., 2011) and direct comparison of the power clean and its potential temporal differences from the full movement has not been investigated.

Thus, the purpose of this study will be to describe temporal, kinematic and kinematic differences that might occur in heavy pulls (112% of 1 RM), a relatively light power clean (80% of 1 RM) and a clean at 90% of 1 RM. Additionally, we will describe any potentiating effects resulting from the heavy pull or power clean on a 90 % of 1 RM squat clean.

Chapter 2. Literature Review

Weightlifting

The sport of Weightlifting currently consists of the snatch and clean and jerk. In competition the combined total of three attempts of the snatch and clean and jerk respectively determines the winner for each body weight class. Weightlifting competition has its roots in ancient Greece and Egypt and has realized steady growth since the first modern Olympiad in 1896 (https://olympics.com/en/sports/weightlifting/).

Optimal Weightlifting Technique

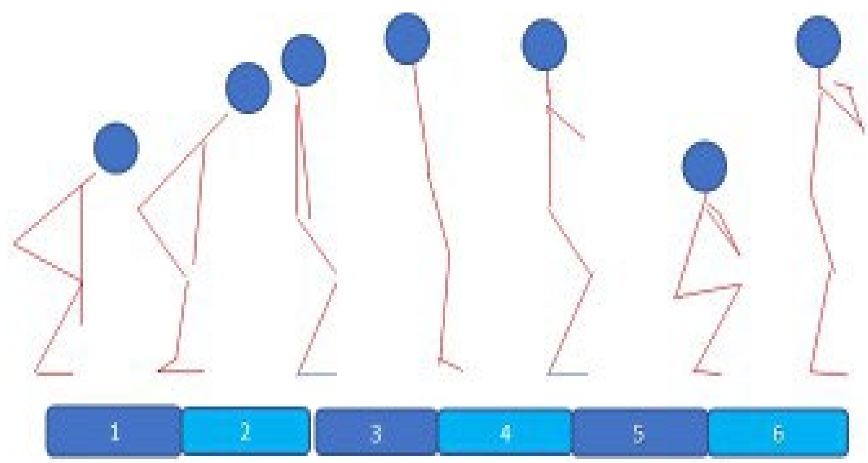
In order to describe positive acute effects following a potentiating movement, it is first necessary to describe optimal technique, and favorable changes to kinetic and kinematic variables in weightlifting movements. The weightlifting movements can be divided into six segments, commonly described below:

1. The first pull: Defined as the period beginning with the first vertical movement of the barbell and concluding just as it passes the knee. Typically characterized by a relatively consistent torso angle with the floor, increasing (extending) knee angle, and posterior translation of the barbell. Notably, barbell velocity and vertical ground reaction force (GRF) increase during this phase.
2. The transition, scoop, or double knee bend: Defined as the period in which the barbell passes the knee joint and concluding before the knee begins to extend. During this critical phase the athlete prepares for the second pull by anterior translation of the knee, combined with decreasing (flexing) knee angle. This phase is sometimes accompanied by a decrease in barbell velocity, and GRF particularly in heavier weight classes, as the athlete transitions to a more optimal position to produce vertical force and accelerate the barbell. The bar at the finish of the transition is usually in light contact with the top of the thigh. The final position prior to

the extension is referred to as the “mid-thigh” or “power” position (Hornsby et al., 2018)

3. The second pull: Defined as the period beginning when the barbell is “pulled” vertically from the top of the thigh and the ankle joint, knee joint, and hip joint reach the greatest angle of extension (often referred to as triple extension) and concludes with a strong shoulder shrug (sometimes referred to as the third pull). At the end of the second pull the athlete is no longer increasing vertical displacement of their center of mass. This phase is accompanied by the greatest barbell velocity and GRF. and is often accompanied by the greatest instantaneous force and barbell acceleration (Garhammer 1998; Cunanan et al., 2020).
4. The turnover phase. Defined as the period beginning with the greatest vertical position of the athlete and concluding with contact of the barbell at the shoulders in the clean or with the palm in the snatch. This phase is often accompanied by athletes repositioning the feet for a more optimal receiving position for the barbell and may include no measurable GRF. It is also in the turnover phase that the barbell begins its descent, and the athlete transitions from the vertical pulling positions to a squat pattern (Garhammer 1998; Cunanan et al., 2020).
5. The catch phase. Defined as the period in which the athlete begins to exert vertical force on the barbell to stop the negative displacement, and concluding with the time in which the barbell begins its ascent again as the athlete stands erect. This phase may begin with barbell contact at the shoulder of the athlete in the front squat position during the clean, or with the hands in the overhead squat position during the snatch (Garhammer 1998; Cunanan et al., 2020).

6. The recovery. Defined as the period in which the athlete begins ascent from the point of fixation and concluding with the highest vertical position of the barbell. In the competed clean and jerk movement, the athlete proceeds to the jerk movement. In the snatch, the exercise is concluded with the recovery (Garhammer 1998; Cunanan et al., 2020).



Six phases of the clean
1: First pull
2: End of 1st pull to beginning of transition
3: End of transition -tobeginning of 2nd pull
4. End of 2nd pull to beginning of turnover
5. End of turnover to start of catch
6. End of catch and start of recovery

Figure 2.1

Phases of the Pull (Modified from Dæhlin (2016) and Cunanan et al., 2020)

The technique of weightlifting can be further divided into 3-4 common trajectories, first described as 3 by Vorobyev (1978) and expanded into 4 by Hiskia (1997). Although there are varying recommendations as to which trajectory has historically been the most optimal (Garhammer 1989, Stone 1998), recent research by Cunanan et al., (2017) indicated that the majority of the lifters at the Pan American and World Weightlifting Championships used type 3 bar trajectory.

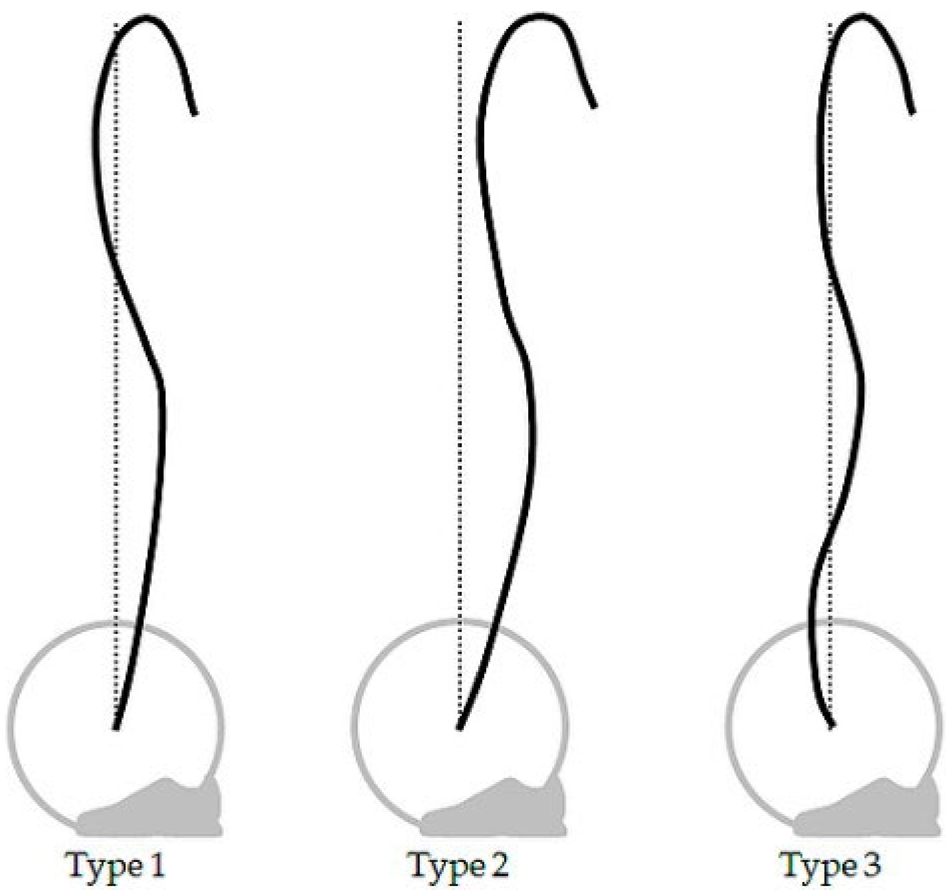


Figure 2.2

Common Pull Trajectories (Modified from Cunanan et al., 2020)

Likely the most predictive factors in success in the weightlifting movements are the trajectory of the barbell (Mastalerz 2019), the acceleration of the barbell during the second pull (Kipp 2015) and subsequently its relative height, as well as the velocity of the athlete's center of mass during the turnover phase (Stone 1998, Mastalerz 2019). Given that the acceleration of the barbell during the second pull is actually a product of the force applied into the ground by the athlete, both the peak force at the mid-thigh or "power" position (Beckham 2013), as well as the net impulse of the athlete during the pulling phases have positive correlations with success of the lifter at increasing weights (Garhammer 1998). Indeed, relationships between strength measures such as squat 1 repetition maximums (1RM), isometric pull and weightlifting performance are highly correlated, as well as net impulse in jumping tasks (Rochau et al., 2024; Stone et al., 2005; Soriano 2024). Furthermore, often at greater loads relative peak force magnitudes are smaller, however, greater impulses can occur as a function of increased time to develop force on the barbell (Garhammer 1998). Although these kinetic and kinematic factors may be maximized to improve performance in the weightlifting movements, case studies have indicated that at novice levels, the importance of barbell velocity may be reduced (Ho 2011) additionally, Kauhanen et al. (1984 and 2000) and Campos et al. (2006) indicated that heavier lifters depend more on extension and barbell velocity, whereas lighter lifters depend more on speed under the barbell. Thus, it may be the case that using either the power clean or heavy pull to prepare for weightlifting competition may be prioritized based on need, such as barbell velocity or speed under the bar, and subsequently be recommended based on proficiency, mass and strength levels of the athlete.

Post Activation Potentiation

The first indications of post activation potentiation were discovered as early as the 1870s by Henry Pickering Bowditch cardiac tissue (Ker 2009), in which cardiac cells increased heart rate likely due to an excess of unutilized calcium from prior contractions. Similar mechanisms of attenuated contractions have been proposed in the skeletal muscle tissue, via increased calcium availability, or most likely resulting in increased myosin chain phosphorylation (Macintosh 1991, Usman 2023). Similar results have been observed in electrically induced tetanic trials, which indicated attenuated peak torque in subsequent contractions after the initial tetanic contractions. Phosphate content of regulatory light chains reflected a similar time course, indicating that phosphorylation of myosin chains is a potential mechanism of post activation potentiation, as well as a potential increase in neurotransmitter activity at the synapse resulting in higher order motor unit recruitment (Lorenz 2011, Tillin 2009). Potential mechanisms of phosphorylation occur due to increase of available calcium and binding of calmodulin, which in turn activates myosin light chain kinase and phosphorylates the myosin regulatory light chain, creating a "potentiated state" that may attenuate a subsequent contraction (Tillin 2009, Oh 2014).

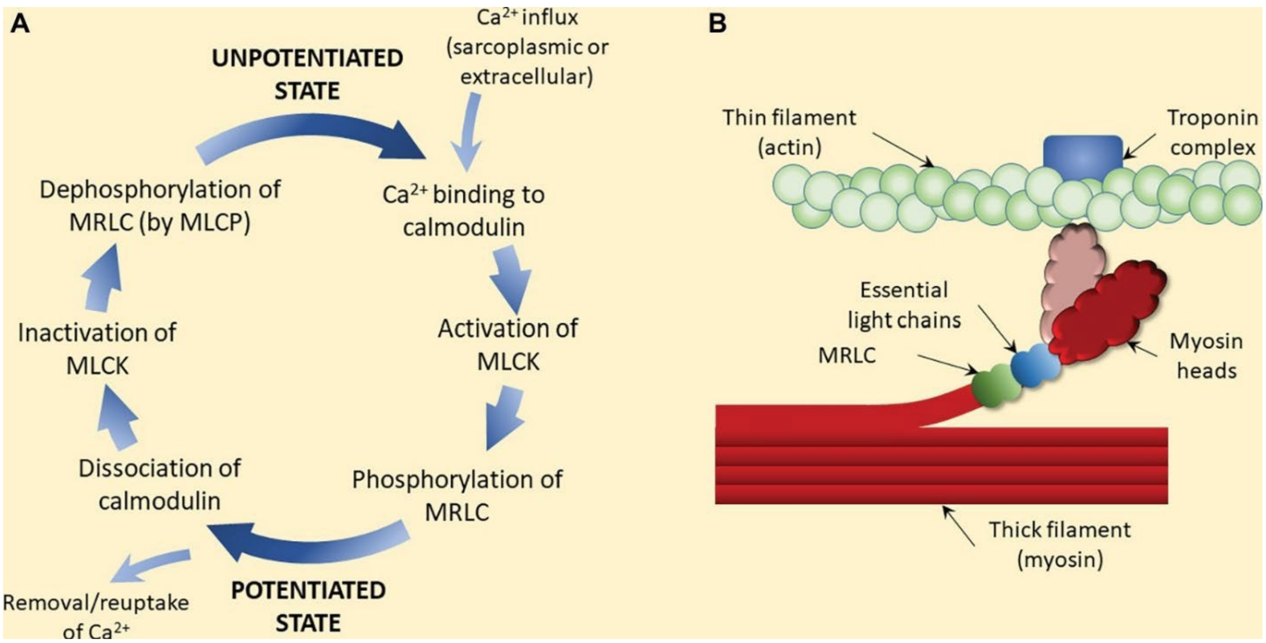


Figure 2.3

Proposed mechanism of Post Activation Potentiation (adapted from Blazevich 2019)

Post Activation Performance Enhancement (Post Exercise Potentiation)

Recent studies suggest that the time course of regulatory chain phosphorylation is not long enough to explain increases in observed performance lasting longer than 30s, and as such there must be different underlying mechanisms improving performance after the initial break. Indeed, studies have shown attenuations in performance as low as five to as high as ten minutes following a potentiating exercise (Wilson 2013, Cuenca-Fernández 2017, Blazevich 2019). Proposed mechanisms include increased muscle temperature, increased calcium sensitivity, decreased pennation angle, improved muscle blood flow, increased "neural drive" or higher order motor unit recruitment and increased muscle activation. Some evidence indicates increased muscle-tendon unit stiffness may contribute to the attenuated repetition, as well as muscle pH, however the effect from both is unlikely to be as large as other proposed mechanisms (Blazevich 2019, Tillin 2009, Mahlfeld 2004; Wallace et al., 2019). Research indicates that relative and absolute strength levels may impact the potentiation effect, including duration of recovery necessary to experience potentiation, as athletes have shown to respond better to potentiation exercises than sedentary individuals (Suchomel 2016).

Chapter 3. Acute kinetic and kinematic effects of the heavy pull and light power as potentiating exercises on the weightlifting clean.

Luke DeVirgiliis, Kevin Carroll, Daniel Gahreman, W. Guy Hornsby, Kyle Pierce, Michael H. Stone

Abstract

The sport of weightlifting has been competed since the first modern Olympiad. Competition in weightlifting consists of 3 attempts the snatch and clean and jerk declared by the athlete and their coach prior to the starting of the lift. While waiting for the athlete's lift, waiting periods can change and warm up attempts may need to be adjusted rapidly. Often, coaches prescribe either a complete "light power" or partial "heavy pull" repetition of the competed movement during a long wait. Previous literature indicates that a heavier stimulus may cause a post activation potentiation, or post activation performance enhancement effect on the subsequent lift. However, some evidence indicates that a heavy pull closely preceding a subsequent clean may disrupt technique. Despite the common practice to perform a heavy pull or lighter power clean or snatch in the warmup area, little information is known about whether this movement will potentiate the following repetition or disrupt technique. Thus, the purpose of this investigation was to investigate the potentiation and technique effects of the heavy pull and light power on a subsequent clean. Methods: The subjects (males n = 9; females n= 2) were eleven well-trained athletes (weightlifting, track and field, crossfit) in the clean. After warmup - a series of cleans were performed leading to a 90 % 1 RM clean followed by a 75% power clean or 112% clean pull, this was followed by a 90% clean. Conditions (light clean or heavy pull) were conducted randomly one week apart. Kinematics were measured using Qualisys M3 motion capture. Subjective effort was measured after each 90% clean using rating of perceived exertion (RPE). (Results: Men were stronger than women how ever there was no difference in the outcome. Peak bar velocity was not statistically different pre-post ($p \geq 0.5$). Vertical displacement was not statistically different pre-post ($p \geq 0.5$). Horizontal displacement was not statistically different ($p \geq 0.5$). Catch phase duration was not statistically different ($p \leq 0.5$), however effect size indicates small to moderate decreases in duration in both conditions. Stronger athletes *appeared* to have less technical disruption compared to lesser lifters. Following the power clean there was a statistically significant reduction in RPE ($p \leq 0.5$, cohen's d=0.595 95%CI=0.171 to 1.02).

Introduction

The sport of weightlifting has been competed since the first modern Olympiad [1]. Competition in weightlifting consists of 3 attempts the snatch and clean and jerk declared by the athlete and their coach prior to the starting of the lift. While waiting for the athlete's lift, waiting periods can change and warm up attempts may need to be adjusted rapidly. Often, coaches prescribe either a complete "light power" or partial "heavy pull" repetition of the competed movement during a long wait as a technical or physiological stimulus [8,9,10]. Previous literature indicates that a heavier stimulus may cause a post activation potentiation, or post activation performance enhancement effect on a subsequent exercise [2,12,14], however some evidence indicates that such practices may disrupt the temporal aspects of a following exercise [4,5,6]. Despite the common practice to perform a heavy pull or lighter power clean or snatch in the warmup area, little information is known about whether this movement will potentiate the following repetition. Thus, the purpose of this investigation is to investigate the potentiation effects of the heavy pull and light power on a subsequent clean.

Methods

Experimental approach to the problem:

This study employed a within subjects repeated measures, crossover design, in which subjects performed a standardized warm up, then a 90% effort clean followed by a potentiating exercise and a subsequent 90% clean. Rest time was set at 2:30 to emulate a competition environment, statistical analysis was performed comparing the first 90% to the second 90% effort.

Subjects:

Eleven subjects (descriptive statistics available in table 3.1), 9 males and 2 females were recruited for this study. Subjects were proficient in the clean, and had competition experience in weightlifting, crossfit or NCAA athletics. The study was approved by the Institutional Review Board, and all subjects provided informed consent prior to participation.

Table 3.1

Descriptive Statistics

Variable		Mean		St.Dev
Age		25.73 years	+/-	4.51 years
Body Mass		92.05 kg	+/-	16.3 kg
	Male	97.2 kg	+/-	11.97 kg
	Female	68.9 kg	+/-	14.8 kg
90% Clean Load		111 kg (121% BM)	+/-	18.3 kg (14% BM)
	Male	118kg (122% BM)	+/-	10.6 kg (13% BM)
	Female	79 KG (117% BM)	+/-	2.12 kg (22% BM)
Allometric Str : (L/(BM^0.67))		5.38	+/-	0.57
112% Heavy Pull Load		135 kg	+/-	20 kg
	Male	143kg	+/-	9.4 kg
	Female	99 kg	+/-	2.8 kg
75% Power Clean Load		92 kg	+/-	15.2 kg
	Male	98 kg	+/-	9.0 kg
	Female	66 kg	+/-	2.1 kg

Testing

Two 90% cleans were assessed on two separate sessions scheduled one week apart (one subject was tested greater than a month apart due to work conflicts). Subjects were instructed to arrive hydrated for their session wearing tight fitting clothing (sports bra, compression short, or weightlifting singlet), hydration was assessed using Urine Specific Gravity (ATAGO 4410 PAL-10S (Tokyo, Japan). Results greater than 1.20 were considered failures, in which participants were instructed to drink water or an electrolyte beverage and retest in 20 minutes. Each subject was assessed for anthropometric measurements using a SECA mBCA 555 Medical Body Composition Analyzer (SECA, Hamburg Germany). Following the anthropometric assessment, subjects were asked to put on their preferred training gear for a weightlifting session, including weightlifting shoes, knee sleeves, wrist wraps. If the subjects elected to wear a belt, they were instructed to put it on when they felt the load warranted it. Subjects filled out a pretest portion of a qualitative assessment, in which they reported their best weightlifting clean in the past 6 months. This value was used to determine the 90% load for all trials, and the loads for the 112% heavy pull and 75% light power clean were also calculated using this value. Subjects were randomly assigned an experimental condition order using a random number generator. All subjects were then fitted with a series of motion capture reflective markers at all major joints and anatomical landmarks, including at least two tracking markers on segments. Subjects performed a static trial on a central weightlifting platform. The barbell was additionally fitted with reflectors. Following the static trial, all anterior joint identification markers were removed to prevent contact with the barbell, and the participants were instructed to begin the warm-up (figure 1).

Figure 3.2

Experimental Protocol

Jumping jacks etc. – 5 min – subjects choice

Clean: 15/20 kgs (Empty Bar) x 5 Reps

Clean 45% x 3 reps

Clean 60% x 3 reps

Clean 75% x 2 reps

Clean 85% x 1 rep

Warm-up

Clean 90% x 1 rep

Potentiating Movement (PC or HP)

Clean 90% x 1 rep

Subjects were provided with 3 minutes of rest between warm up repetitions during the warm- up and 2 minutes and 30 seconds between the testing repetitions and the potentiating movement to emulate competition. Following the first repetition at 90%, subjects were instructed to fill out their RPE on a 1-10 ordinal scale. After the potentiating movement and subsequent 90% effort clean, subjects repeated the RPE measurement. Each 90% repetition was filmed using 8 Miqus M3 motion capture cameras (Qualisys, Göteborg Sweden) stationed at random heights and locations around the capture area sampling at 100Hz. Motion capture data was recorded using Qualisys Track Manager and processed into Visual3D after gap filling using a linear interpolation window set at 10 frames. Lab orientation was calibrated prior to each testing session, Z axis represents vertical movement, X axis represents Anterior-Posterior movement, Y axis represents medial lateral movement. Samples were then analyzed in Visual3D using the motion of the left side of the barbell and the C7 or the most superior 100% captured marker to determine phases of the weightlifting clean, acceleration was smoothed using a butterworth low pass filter set at 6hz. Phases were determined using the criteria outlined in table 3.2.

Table 3.2

Phase Identification Criteria

Phase	Start Point	End Point
1st Pull	First “Z” movement of barbell	0 “Z” Acceleration following start of movement (marked on descent)
Transition	End of 1st Pull*	0 “Z” Acceleration following start of movement (marked on ascent)
2nd Pull	End of Transition**	Greatest “Z” position of C7 or next most superior marker
Turnover	End of 2nd Pull	Positive “Z” change in acceleration of barbell
Catch	End of Turnover	0 Velocity of barbell

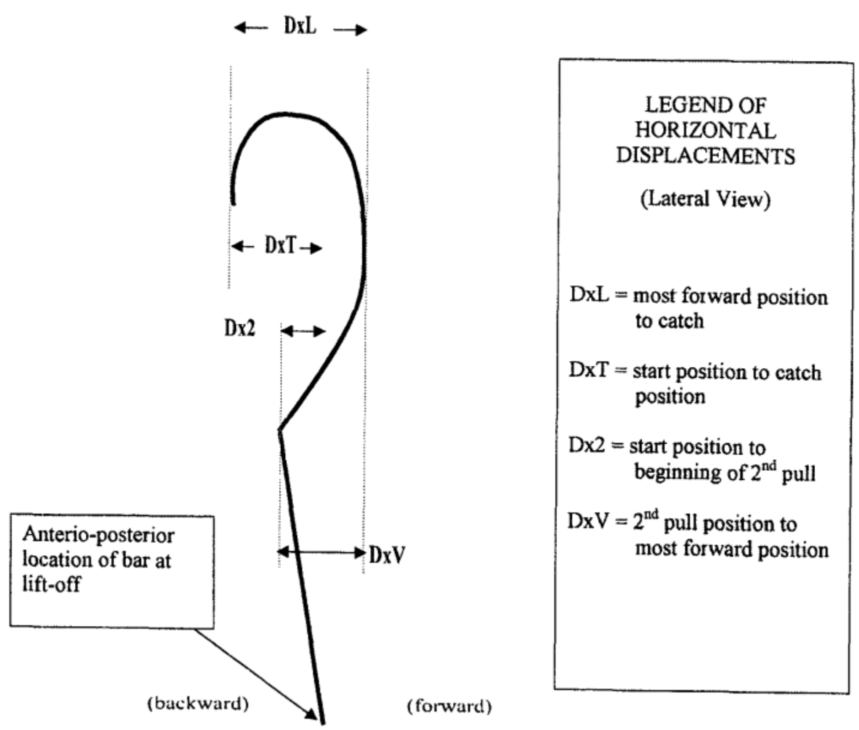
Recovery	End of Catch	Greatest "Z" postition of barbell

*In instances where no clear "0" acceleration occurred; most posterior knee position was used.
**In instances where no clear "0" acceleration occurred; most anterior knee position was used.

Calculated pulling related metrics using the vertical axis included average barbell velocity during pulling phases, maximum velocity of the barbell and maximum barbell height during the pull, and barbell height at the end of the pull. Catch-related metrics included turnover and catch phase duration, and barbell height at the end of the turnover. Anterior posterior metrics followed the model indicated in Stone 1998 [11] for snatch analysis (fig. 3.2).

Figure 3.2

Anterior-Posterior Metrics



(Adapted from Stone et al., 1998 [11])

Statistical Analysis

Paired sample T-Test was performed to determine if significant differences existed between pre-testing conditions (Fig. 3.3). No variables were deemed significant at an alpha of $p \leq 0.05$.

Table 3.3

Paired Sample T-Test Results

Paired Samples T-Test

Measure 1		Measure 2	t	df	p	Cohen's d	SE Cohen's d	95% CI for Cohen's d Lower	Upper
RPE Pre HP	-	RPE Pre PC	−1.480	10	0.170	−0.446	0.263	−1.058	0.185
1ST DURATION Pre HP	-	1ST DURATION Pre PC	−0.329	10	0.749	−0.099	0.113	−0.689	0.496
2ND DURATION Pre HP	-	2ND DURATION Pre PC	−1.208	10	0.255	−0.364	0.101	−0.967	0.256
2ND MAX VELO Pre HP	-	2ND MAX VELO Pre PC	0.253	10	0.805	0.076	0.160	−0.517	0.666
BB HEIGHT AT END OF 2ND PULL Pre HP	-	BB HEIGHT AT END OF 2ND PULL Pre PC	−0.985	10	0.348	−0.297	0.104	−0.895	0.315
BB HEIGHT AT END OF TURNOVER 2 Pre HP	-	BB HEIGHT AT END OF TURNOVER 2 Pre PC	0.137	10	0.894	0.041	0.116	−0.551	0.631
CATCH DURATION Pre HP	-	CATCH DURATION Pre PC	0.168	9	0.870	0.053	0.227	−0.569	0.672
Dx2 Pre HP	-	Dx2 Pre PC	−0.630	10	0.543	−0.190	0.204	−0.782	0.411
DxL Pre HP	-	DxL Pre PC	0.310	10	0.763	0.093	0.094	−0.501	0.683
DxT Pre HP	-	DxT Pre PC	−0.676	10	0.515	−0.204	0.230	−0.796	0.399
DxV Pre HP	-	DxV Pre PC	−0.776	10	0.456	−0.234	0.221	−0.828	0.371
MAX HEIGHT BARBELL Pre HP	-	MAX HEIGHT BARBELL Pre PC	−0.657	10	0.526	−0.198	0.108	−0.790	0.404
TRANSITION DURATION Pre HP	-	TRANSITION DURATION Pre PC	1.199	10	0.258	0.361	0.368	−0.258	0.964
TURNOVER DURATION Pre HP	-	TURNOVER DURATION Pre PC	−1.104	10	0.295	−0.333	0.184	−0.933	0.283
BB_VELO_1ST Pre HP	-	BB_VELO_1ST Pre PC	−0.179	10	0.861	−0.054	0.129	−0.644	0.539
BB_VELO_2ND Pre HP	-	BB_VELO_2ND Pre PC	−0.393	10	0.702	−0.119	0.146	−0.709	0.478
BB_VELO_PULL Pre HP	-	BB_VELO_PULL Pre PC	−0.338	10	0.742	−0.102	0.143	−0.692	0.493
BB_VELO_TRANS Pre HP	-	BB_VELO_TRANS Pre PC	−0.664	10	0.522	−0.200	0.133	−0.793	0.402

Note. Student's t-test.

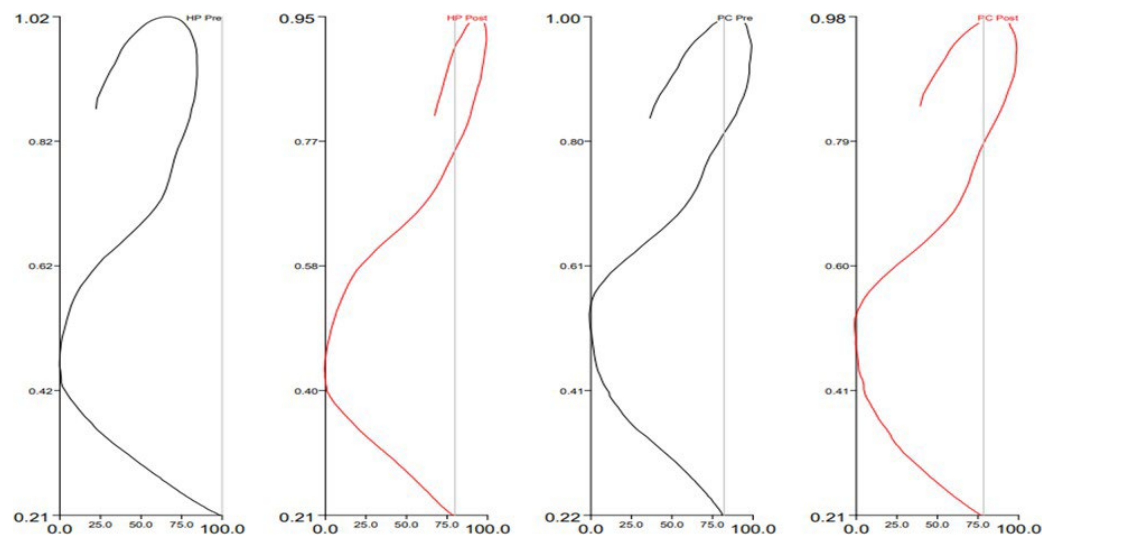
A repeated measures ANOVA was used for statistical analysis with holm corrections. A-priori statistical power was calculated using G*Power (Version 3.19.7) resulting in a minimum sample size of 10 with correlation between repeated measures of r=0.9, alpha level was set at p ≤0.05 and power at 0.85. Subsequent observed power ranged from 0.21 TO 0.91, averaging 0.69.

Statistical processing was performed using JASP (JASP Team, 2024, Version 19.0). A less conservative Mixed Model 2x2 ANCOVA was also performed to assess within subjects conditions, however a-prior power analysis resulted in a required sample size of 400, likely indicating an inappropriate analysis for this population. Qualitative analysis was conducted using vertical and anterio-posterior displacement of the barbell during the pull using a visual3D generated graph of barbell trajectory. X axis was normalized from anterior posterior range as 0-100% for comparison and the calculated displacement was graphed on the y axis (Fig 4). Subjects were divided into two groups (5 strongest and 5 weakest) to qualitatively assess the influence of strength on technique following potentiation.

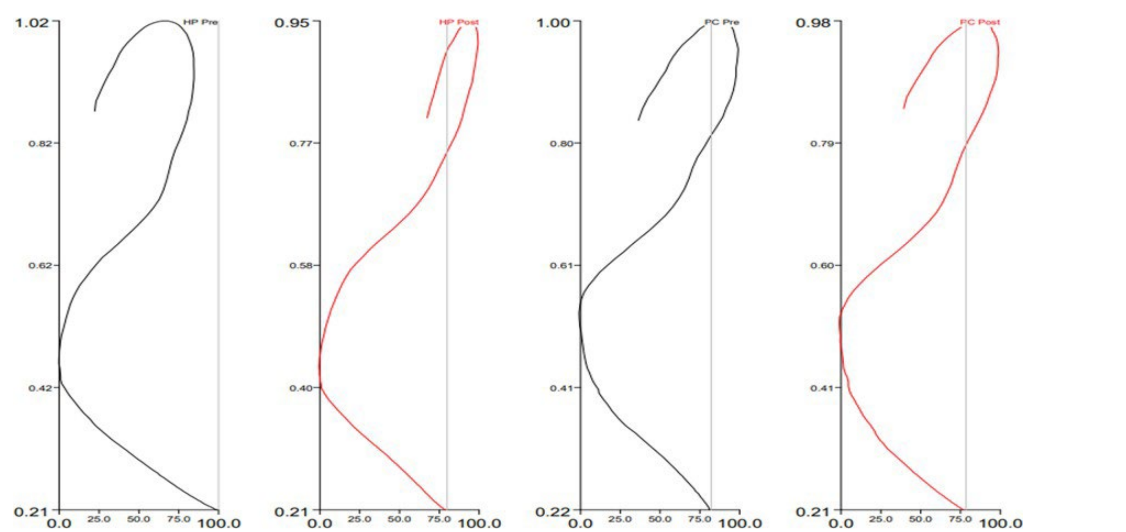
Figure 3.3

Qualitative Analysis of the Pull

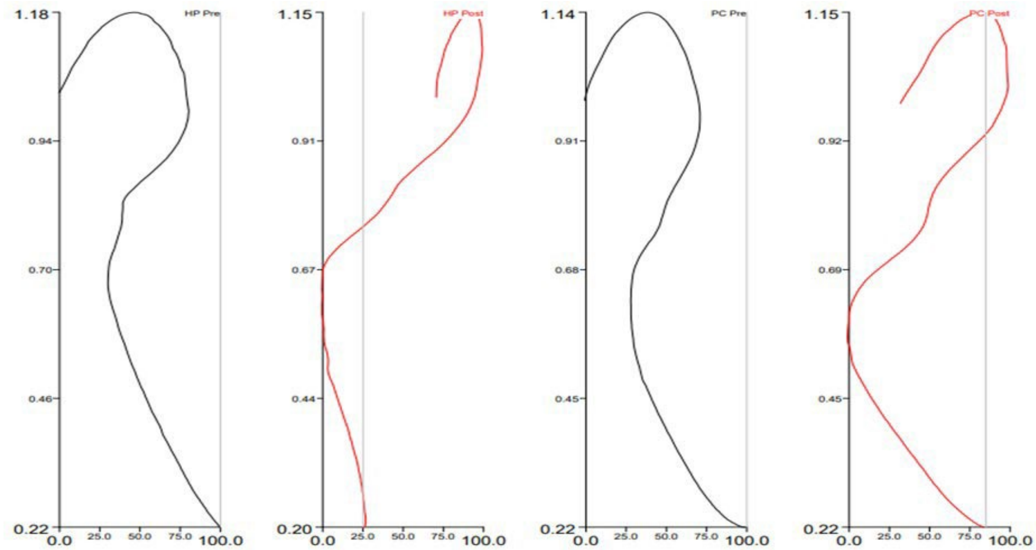
Heavy Pull Pre	Heavy Pull Post	Power Pre	Power Post



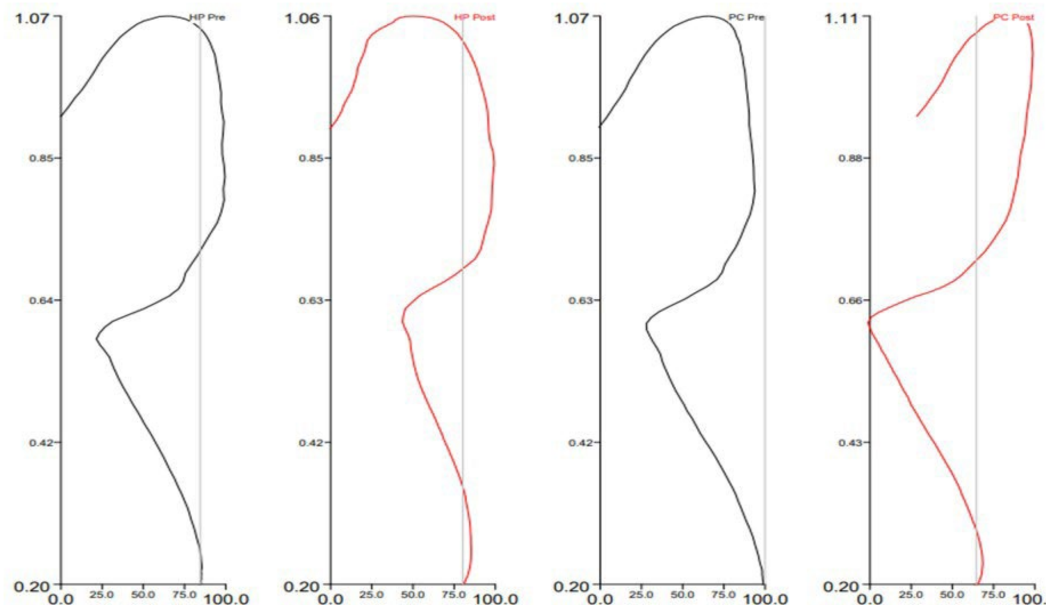
&Subject 1: Barbell travels more posterior following power clean intervention.



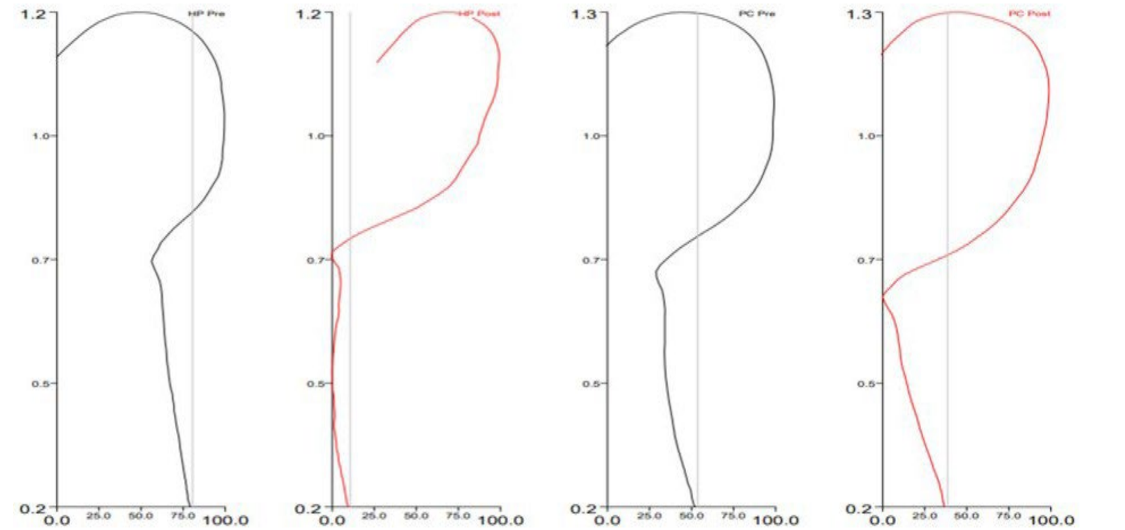
#Subject 2 : Barbell travels more anterior following heavy pull intervention.



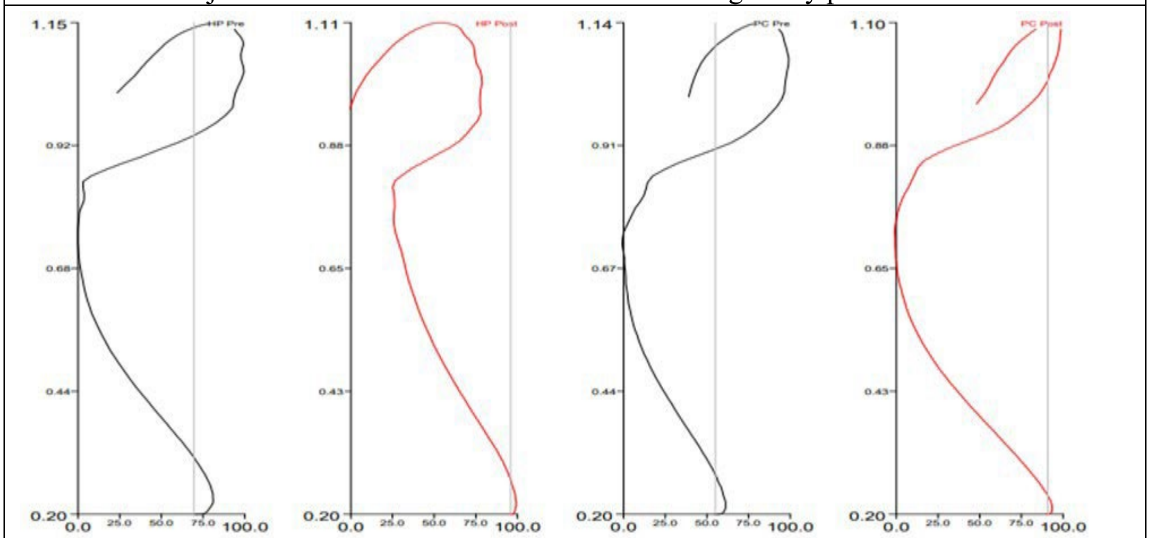
#Subject 3: Barbell travels more anterior following both interventions, greater in heavy pull.
**Both post-test repetitions were unsuccessful.



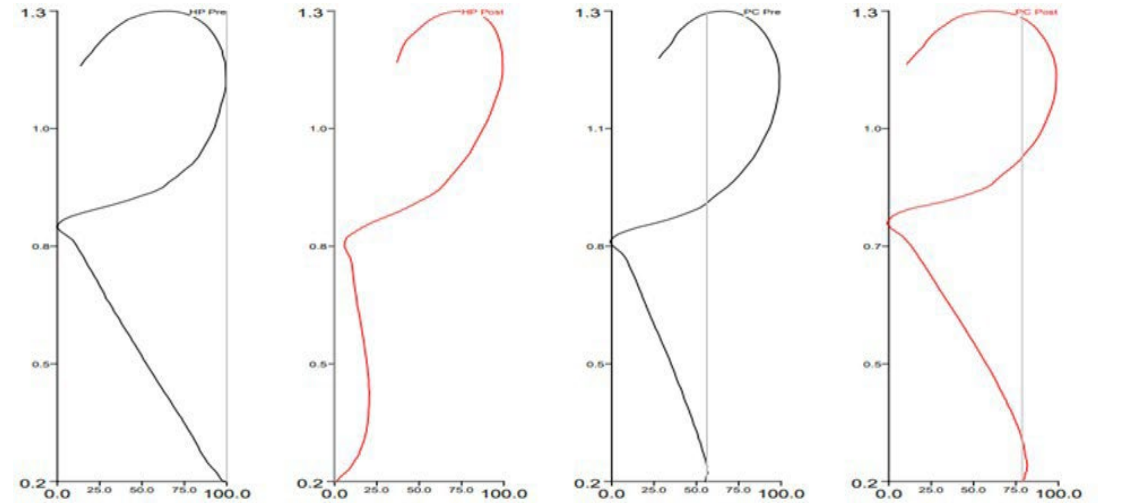
&Subject 4: Barbell travels more anterior following power clean intervention.



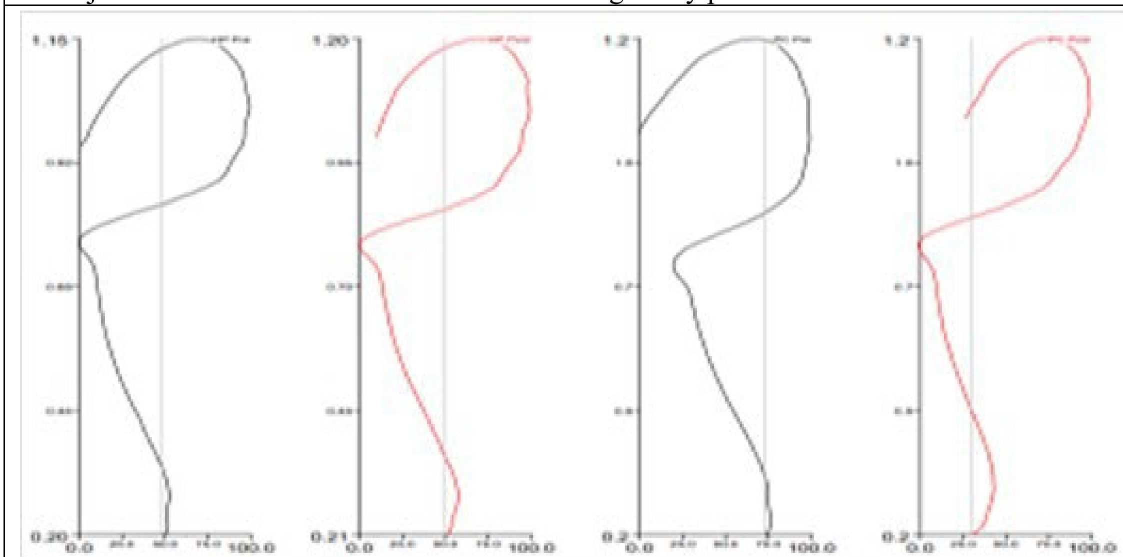
&Subject 5: Barbell travels more anterior following heavy pull intervention.



#Subject 6: Barbell travels more posterior following both interventions, greater in heavy pull.

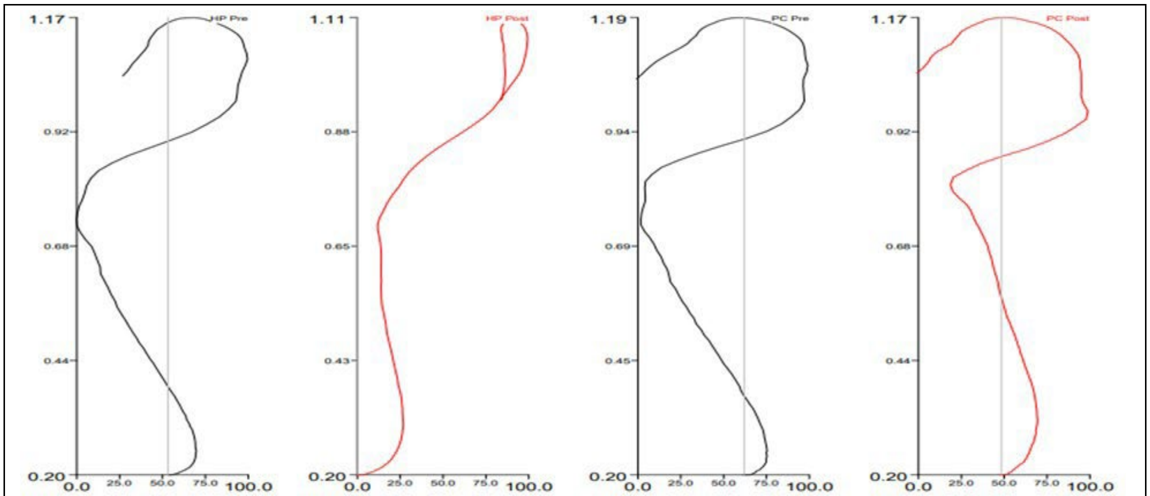


&Subject 7: Barbell travels more anterior following heavy pull intervention.

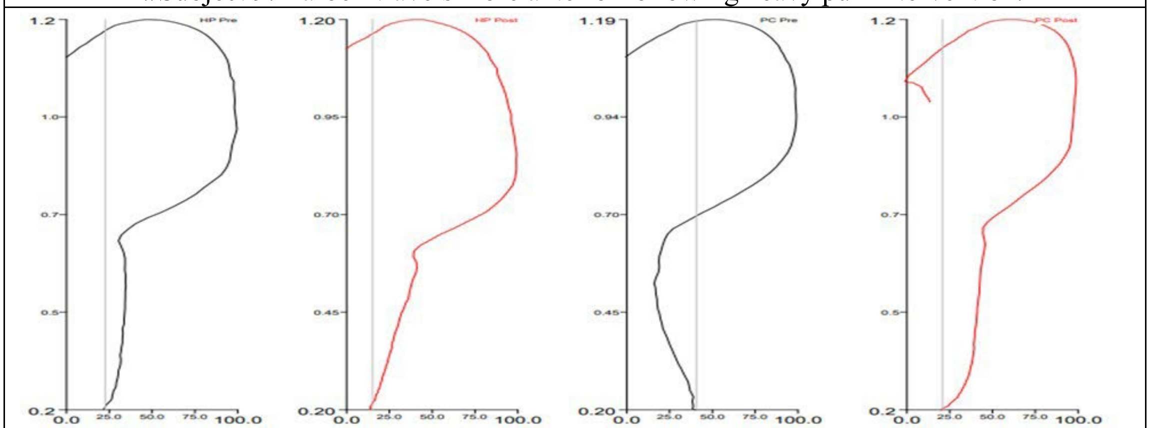


&Subject 8: Barbell travels more anterior following power clean intervention.

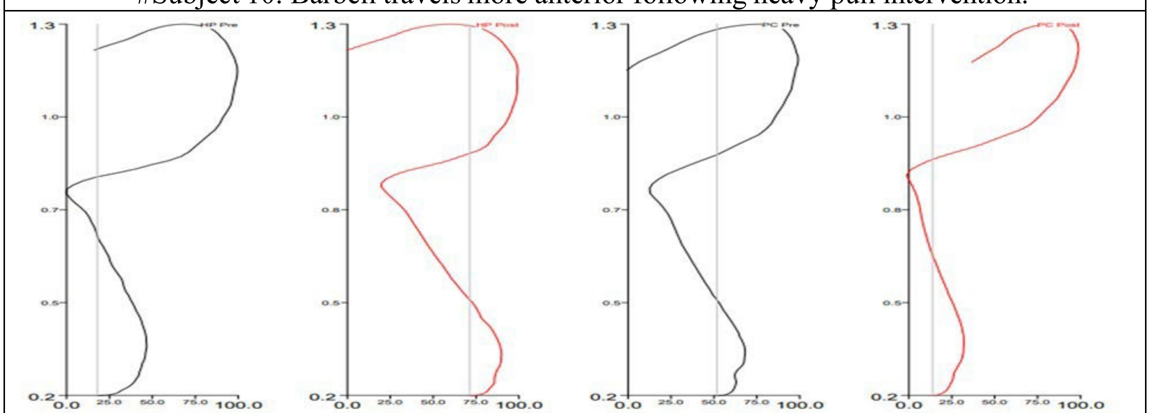
**Pre-test Heavy Pull repetition was unsuccessful; post-test repetition was successful.



#Subject 9: Barbell travels more anterior following heavy pull intervention.



#Subject 10: Barbell travels more anterior following heavy pull intervention.



travels more anterior following power clean intervention, barbell travels more posterior following heavy pull intervention.

# indicates stronger group athlete

n=5 & indicates weaker group

athlete n=5

(Barbell trajectories modeled after Cunanan et al., [3]) Results

Repeated measures ANOVA indicated statistically significant main effects for time in rating of perceived exertion, planned contrasts revealed significant differences at HP POST – PC PRE (p= 0.025, Cohen's d=0.595 (95% CI =-1.178 to -0.013)), as well as PC PRE – PC POST (p=0.001, Cohen's d=0.595 (95% CI = 0.171 to 1.020)). No additional main effects were found between any groups for all variables examined. Qualitative analysis may indicate that subjects respond differently to each stimulus, despite the lack of statistical significance. Notably, subject 3 failed both repetitions following the potentiating exercise; whereas subject 9 failed the repetition prior to heavy pull but was successful following the potentiating exercise.

Table 3.3

Statistical Results

RPE

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	ω²
Time	11.045	3	3.682	3.568	0.026	0.041
Residuals	30.955	30	1.032			

Note. Type III Sum of Squares

Between Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p
Residuals	139.045	10	13.905		

Note. Type III Sum of Squares

Descriptives

Descriptives

Time	N	Mean	SD	SE	Coefficient of variation
HP PRE	11	6.682	2.411	0.727	0.361
HP POST	11	6.273	2.328	0.702	0.371
PC PRE	11	7.5	1.396	0.421	0.186
PC POST	11	6.273	1.954	0.589	0.312

Contrast Tables

Repeated Contrast - Time

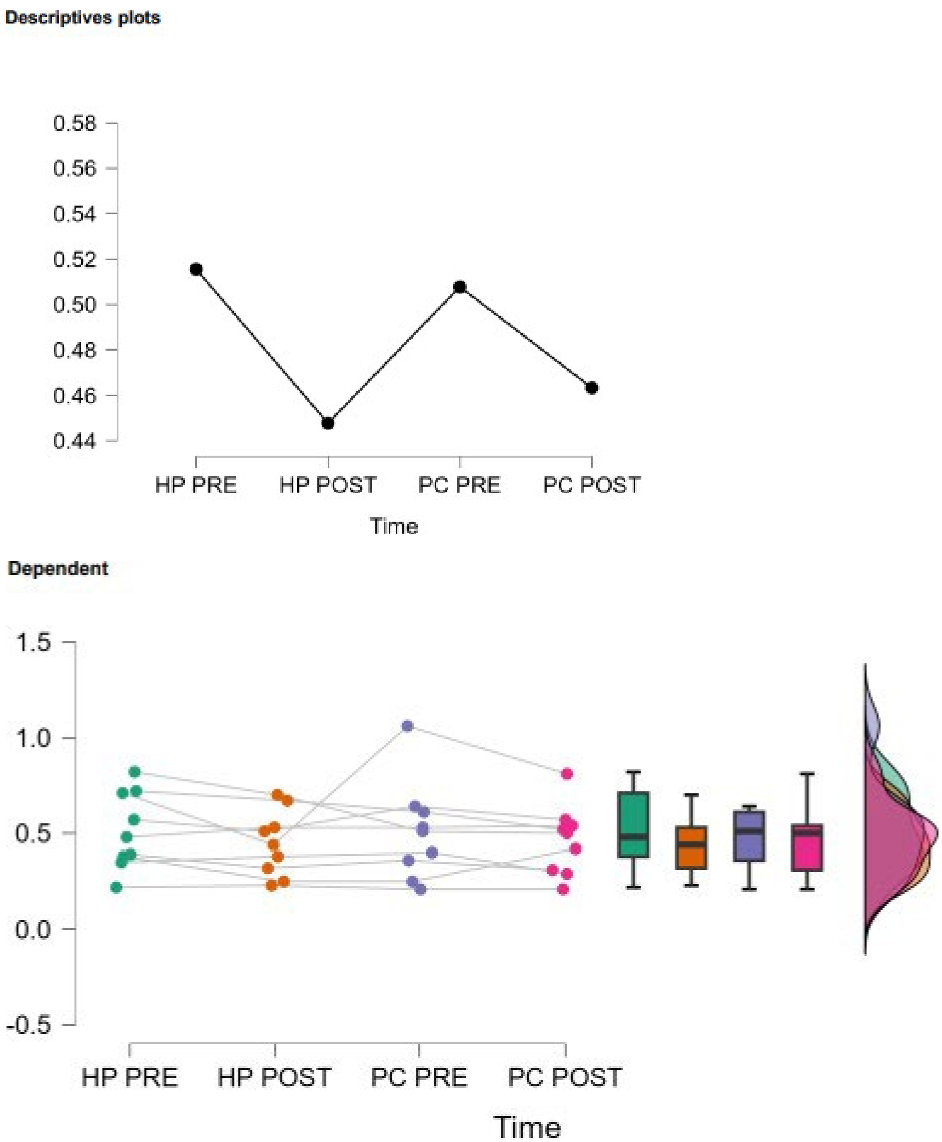
		95% CI for Mean Difference							95% CI for Cohen's d	
Comparison	Estimate	Lower	Upper	SE	df	t	p	Cohen's d	Lower	Upper
HP PRE - HP POST	0.409	-0.308	1.127	0.322	10	1.27	0.233	0.198	-0.163	0.56
HP POST - PC PRE	-1.227	-2.261	-0.193	0.464	10	-2.645	0.025	-0.595	-1.178	-0.013
PC PRE - PC POST	1.227	0.601	1.853	0.281	10	4.368	0.001	0.595	0.171	1.02

Discussion

The primary findings from this study suggest that although prior evidence may indicate temporal disruption resulting from a heavy pull [6], there was no statistically significant differences in phase duration of a 90% clean following a heavy pull at 112% or a light power clean at 75%. Although there were no significant differences in quantitative variables following the heavy pull and light power clean interventions, rating of perceived exertion did decrease when performing the light power in between attempts. Additional trends were observed in reductions of catch phase duration, although only at a small effect size (HP Cohen's d = 0.331 95%CI −0.085 to 0.747, PC Cohen's d = 0.217 95%CI −0.224 to 0.658) and not significant (HP $p= 0.072$, PC $p= 0.270$), subjects trended toward reduction in catch phase durations following both interventions (Figure 3) RPE change may be a result of reduced mechanical work performed during the power clean intervention. As research indicates that myosin regulatory chain phosphorylation may cease to provide a potentiating effect within 30 seconds, different mechanisms such as increased neural drive, increased blood flow, and increased muscle temperature may be contributing factors to potentiation [2,13,14,15]. Greater rest intervals than the 150 seconds utilized in this study to emulate competition may result in more significant outcomes. Future studies should entail investigations using a similar design with varying rest between trials, additional qualitative and quantitative metrics regarding nervous system activation should be examined.

Figure 3.4

Catch Phase Durations



Qualitative analysis indicates that changes in technique following a heavy pull or a light power can lead to increased anterior displacement of the barbell at the second pull, however, these findings seem to be somewhat individualized. Previous investigations have indicated that athletes may utilize different strategies to accomplish a lift dictated by their skill level and body weight [5, 6, 7]. Additional strategy changes have been observed in elite and novice weightlifters following increases in loads from 70-100%, in which decreases in barbell velocity, barbell height and increases in turnover phase durations were observed. In the case of elite weightlifters, shorter phases were observed during the jerk movement when compared to district level lifters [5]. This investigation indicated no common variables between athletes that experienced technical changes, favorable or unfavorable, following a potentiating exercise, however the lack of technical proficiency in the lift may have been a confounding factor in an observed change.

Practical Applications

Weightlifting coaches should consider implementation of the power clean and light pull as exercises utilized prior to heavy clean attempts if they observe favorable changes in technique in their athletes. As this may be individualized, coaches should take care in prescribing the exercise that results in the best technique of their athlete in the subsequent repetition.

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Chapter 4. Discussion and Future Directions for Research

Primary Findings

The primary findings from this study are that although prior evidence may indicate temporal disruption resulting from a heavy pull (Häkkinen & Kauhanen 1986), there was no statistically significant differences in phase duration of a 90% clean following a heavy pull at 112% or a light power clean at 75%. Although there were no significant differences in quantitative variables following the heavy pull and light power clean interventions, rating of perceived exertion did decrease when performing the light power in between attempts. Additional trends were observed in reductions of catch phase duration, although only at a small effect size (HP Cohen's d = 0.331 95%CI −0.085 to 0.747, PC Cohen's d = 0.217 95%CI −0.224 to 0.658) and not significant (HP $p= 0.072$, PC $p= 0.270$). Qualitative analysis indicates that changes in technique following a heavy pull or a light power can lead to increased anterior displacement of the barbell at the second pull, however, these findings seem to be somewhat individualized.

Discussion and Directions for Future Research

Previous investigations have indicated that athletes may use different strategies to accomplish a lift dictated by their skill level and body weight (Häkkinen & Kauhanen 1986, Ho, 2011). Additional strategy changes have been observed in elite and novice weightlifters following increases in loads from 70-100%, in which decreases in barbell velocity, barbell height and increases in turnover phase durations were observed. In the case of elite weightlifters, shorter phases were observed during the jerk movement when compared to district level lifters (Häkkinen, 1984). This investigation indicated no common variables between athletes that experienced technical changes, favorable or unfavorable, following a potentiating exercise, however the lack of technical proficiency in the lift may have been a confounding factor in an observed change. Future research should consider more technically proficient and stronger subjects to maintain a more homogeneous sample. Future investigations should investigate the long-term effects of using the heavy pull or light power clean prior to the clean on technical improvements.

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APPENDICES

Appendix A: Questionnaire

Please complete the following information:

Subject

____

Best Total (Snatch & Clean and Jerk) in the past 6 months

____

Best Training Clean in the past 6 Months ______

90% Clean ______

In competition, if you experience a long wait between attempts, do you prefer:

A light power clean

A heavy clean pull

Which do you think will improve your subsequent clean more:

A light power clean

A heavy clean pull

Subjective Measures:

Rate your perceived exertion on a scale of 1:10 following the first effort

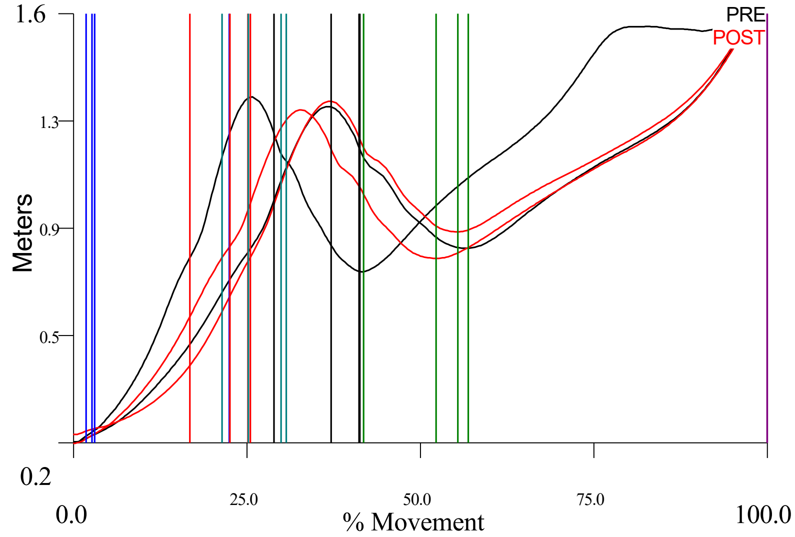
1 2 3 4 5 6 7 8 9 10

Rate your perceived exertion on a scale of 1:10 following the second effort

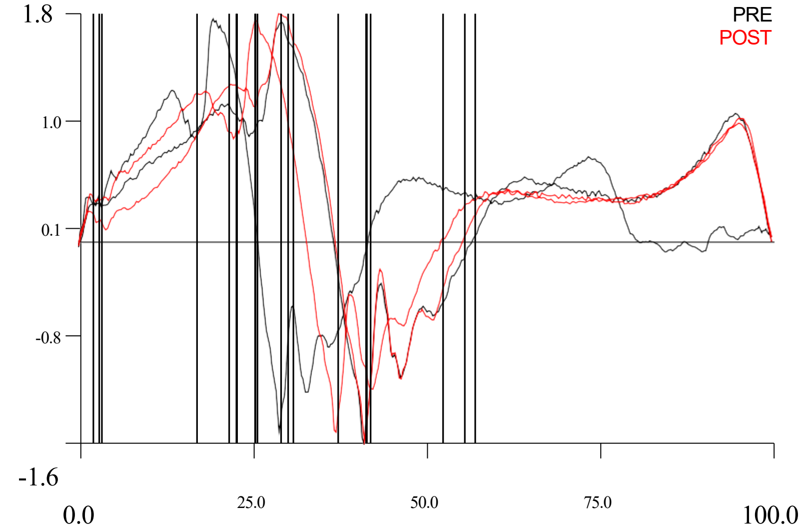
1 2 3 4 5 6 7 8 9 10

Appendix B: Athlete Reports and Qualitative Analysis

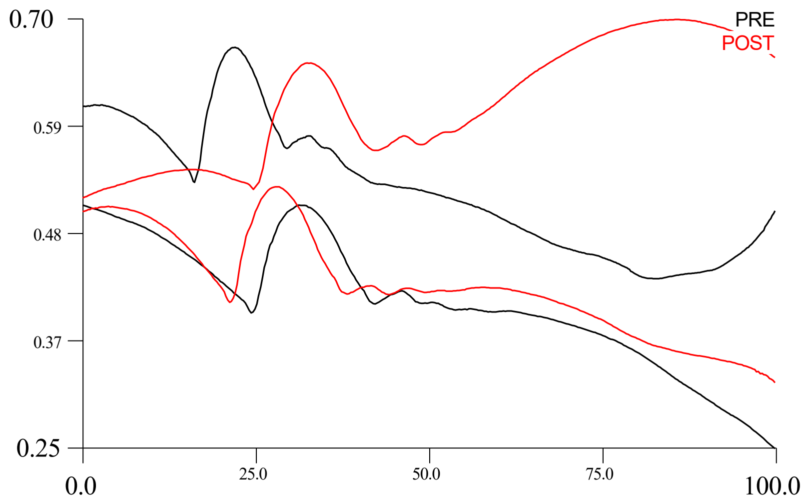
Z POS



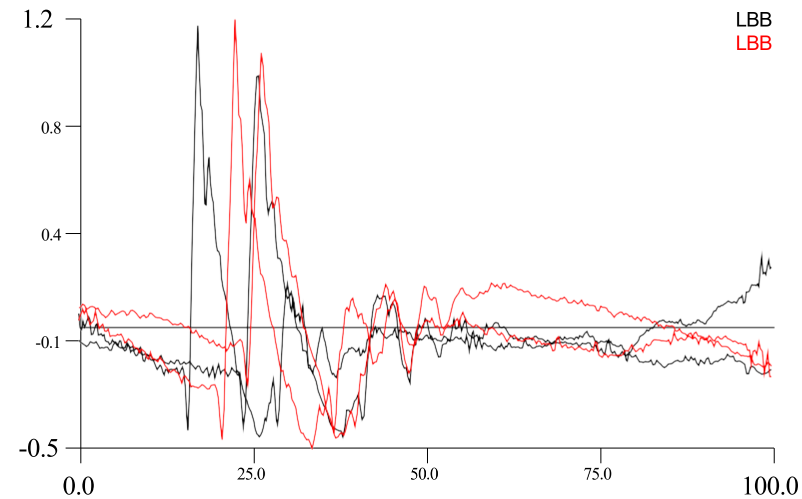
Z VELO



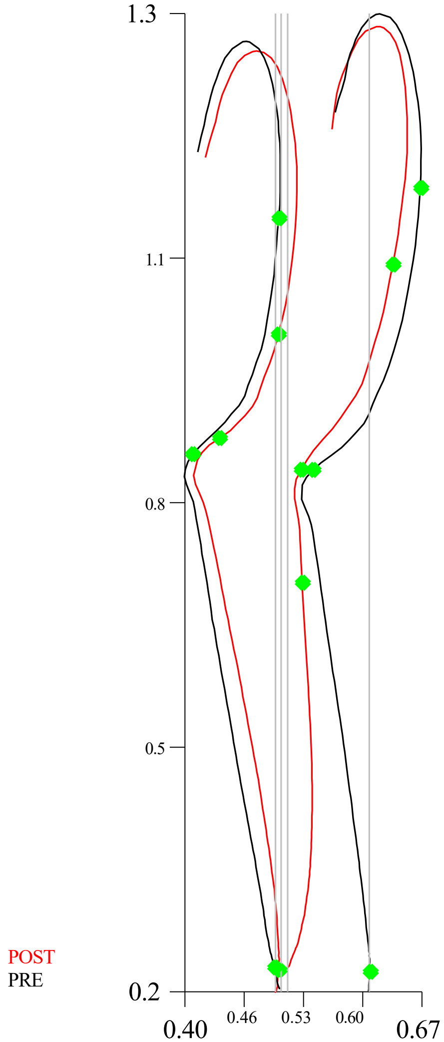
X POS

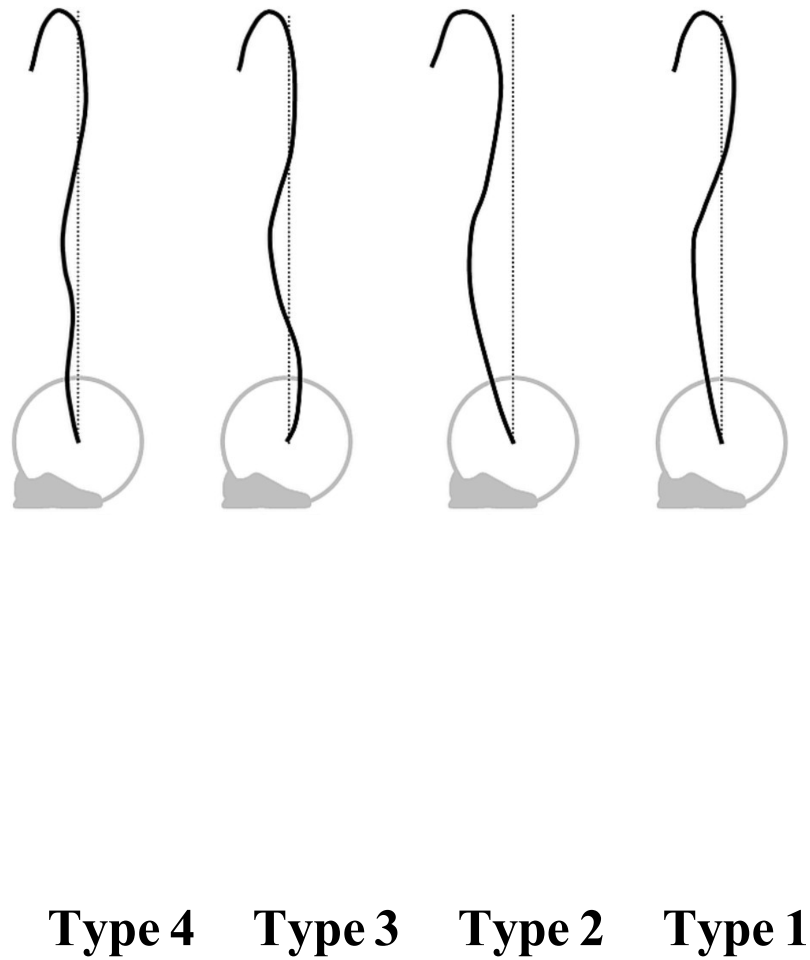


X VELO



Barbell Trajectory



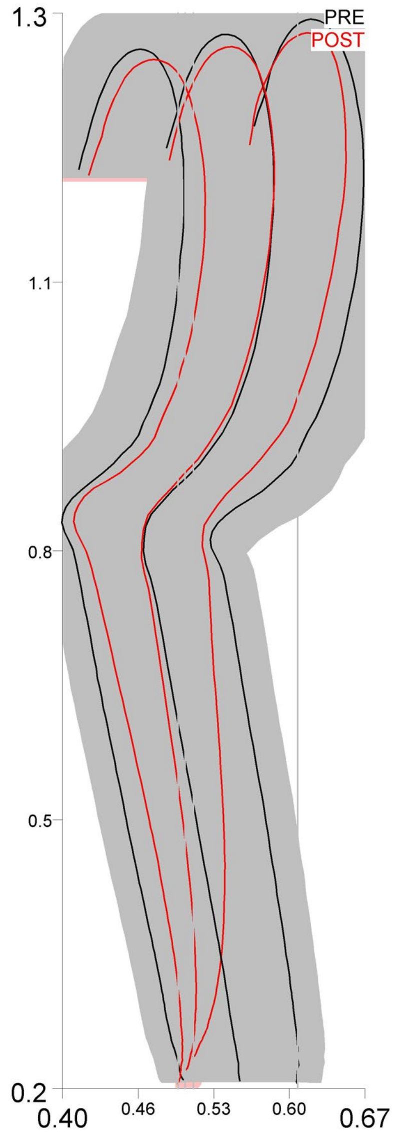


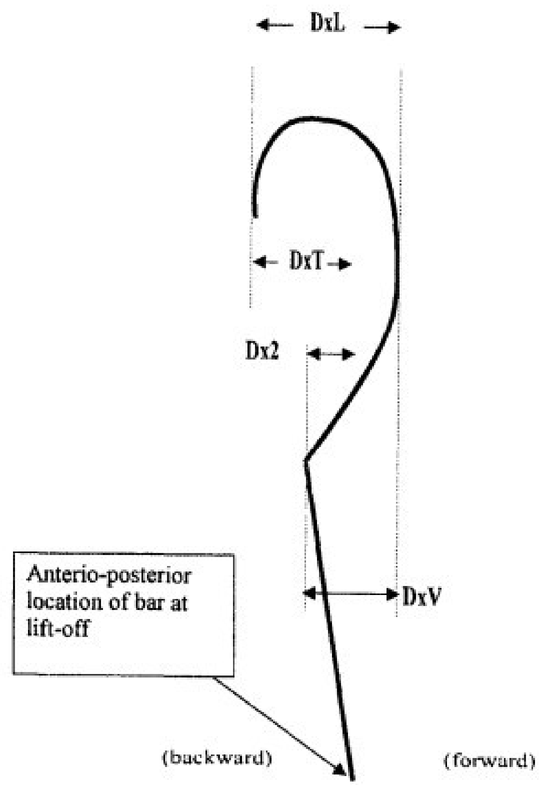
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.768 ; 1.794	1.304 ; 1.336	1.097 ; 1.132	1.175 ; 1.221	-1.658 ; -1.801	0.110 ; 0.090	0.200 ; 0.230	0.380 ; 0.370	1.560 ; 2.880
POST	1.834 ; 1.738	1.321 ; 1.292	1.043 ; 0.961	1.201 ; 1.168	-1.532 ; -1.710	0.810 ; 0.100	0.160 ; 0.100	0.410 ; 0.450	1.610 ; 1.800

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.096 ; -0.100	-0.088 ; -0.107
DxT: START TO CATCH	-0.096 ; -0.039	-0.011 ; -0.081
Dx2: START TO START OF 2ND PULL	-0.103 ; -0.065	-0.047 ; -0.065
DxV: 2ND PULL POSITION TO MOST FORWARD	0.103 ; 0.126	0.124 ; 0.090





LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

DxL = most forward position to catch

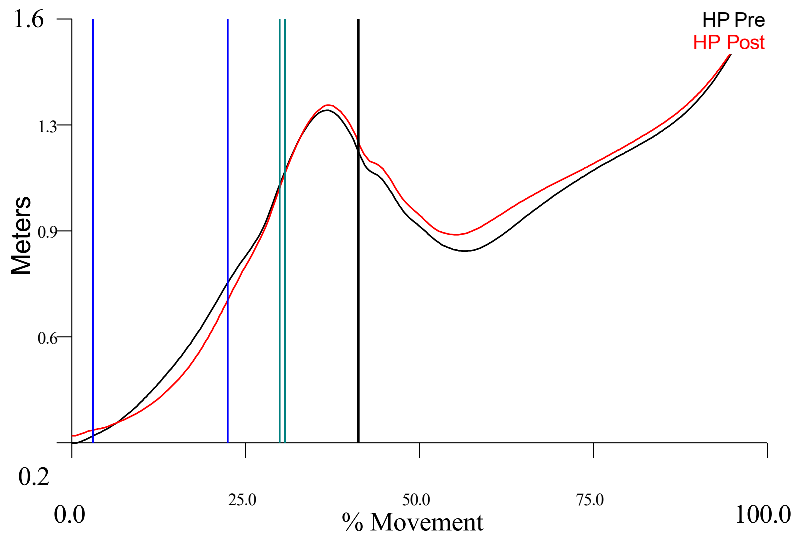
DxT = start position to catch position

Dx2 = start position to beginning of 2nd pull

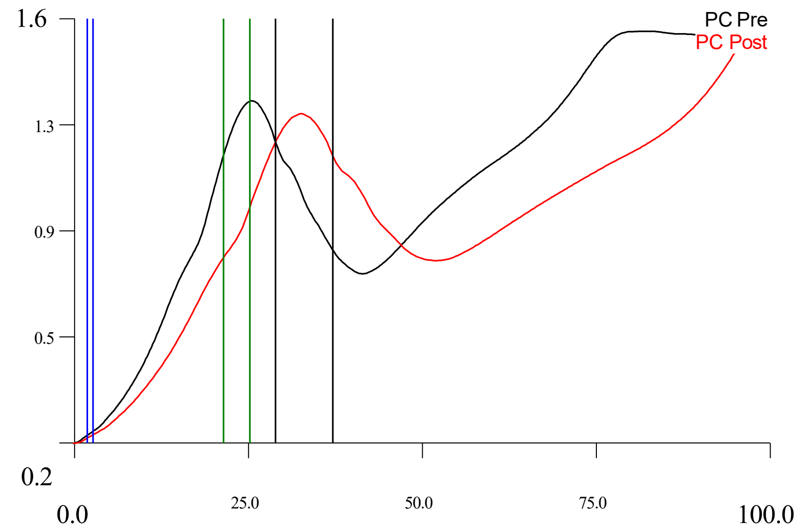
DxV = 2nd pull position to most forward position

ATHLETE Report

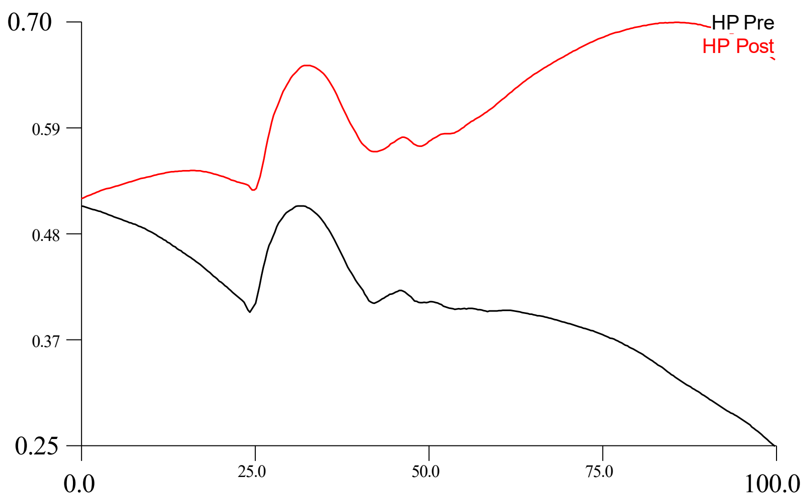
Z POS HP



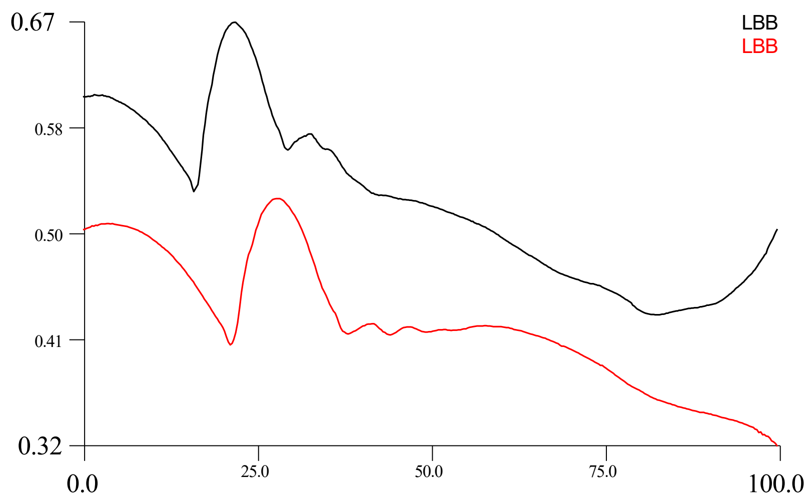
Z POS PC



X POS HP

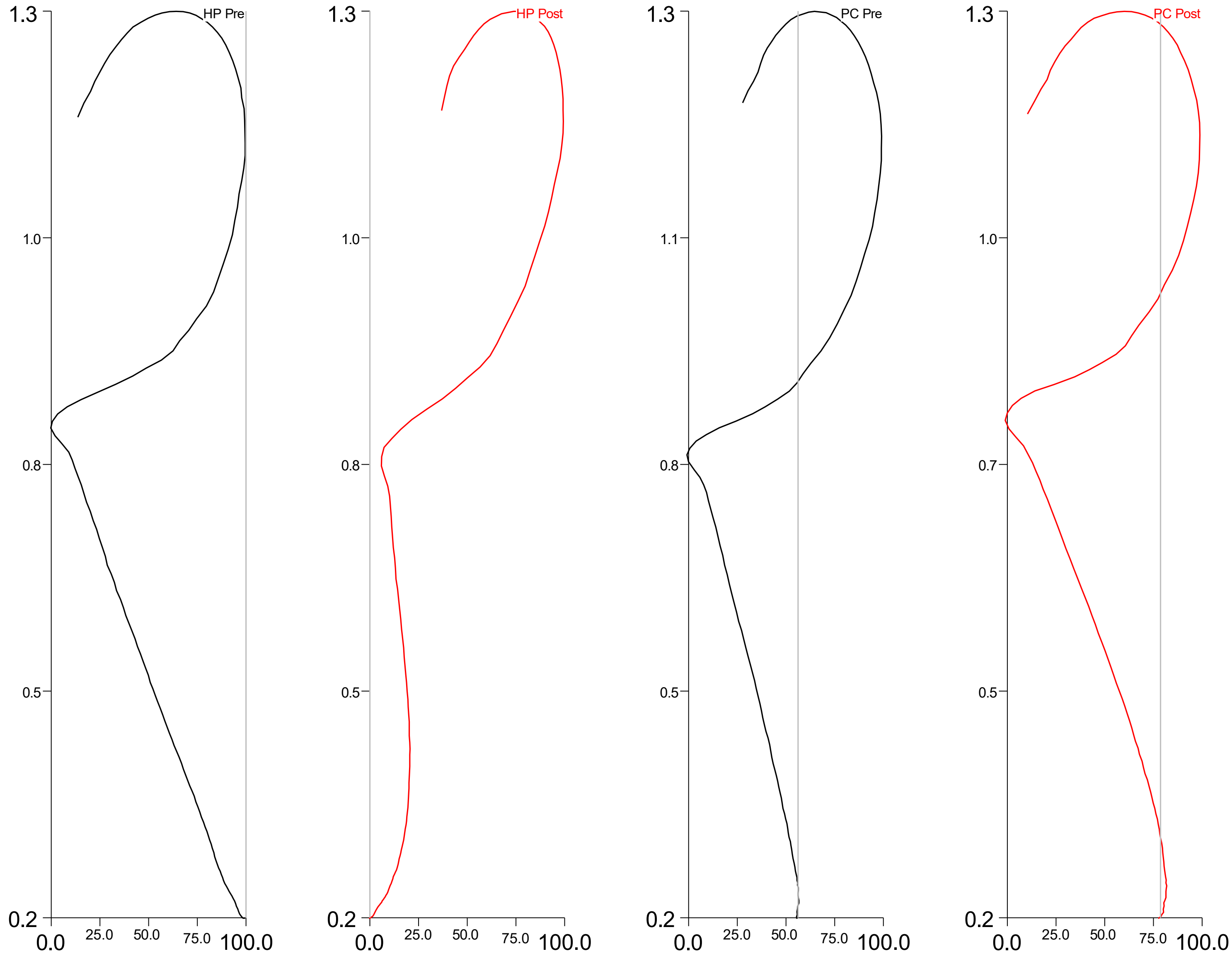


X POS PC



ANTERIOR POSTERIOR CHANGES HP VS PC

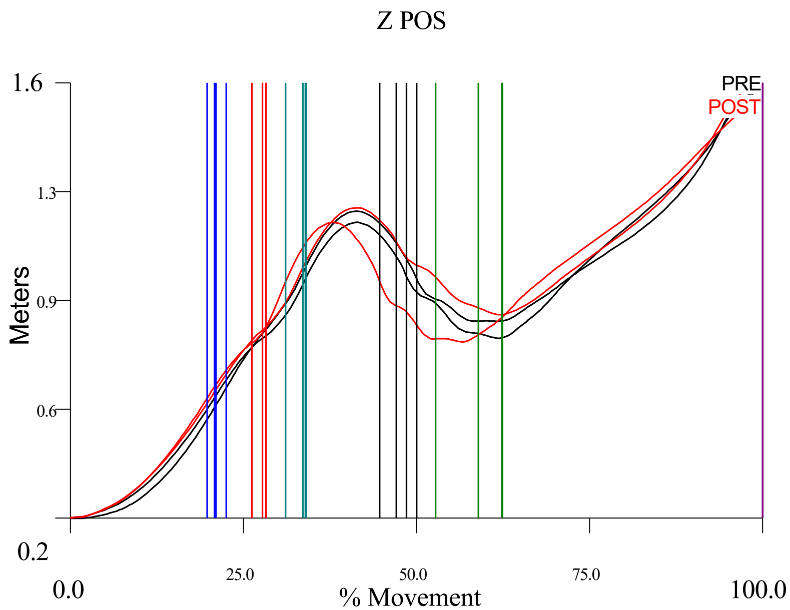
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.096	-0.088	-0.100	-0.107
DxT: START TO CATCH	-0.096	-0.011	-0.039	-0.081
Dx2: START TO START OF 2ND PULL	-0.103	-0.047	-0.065	-0.065
DxV: 2ND PULL POSITION TO MOST FORWARD	0.103	0.124	0.126	0.090

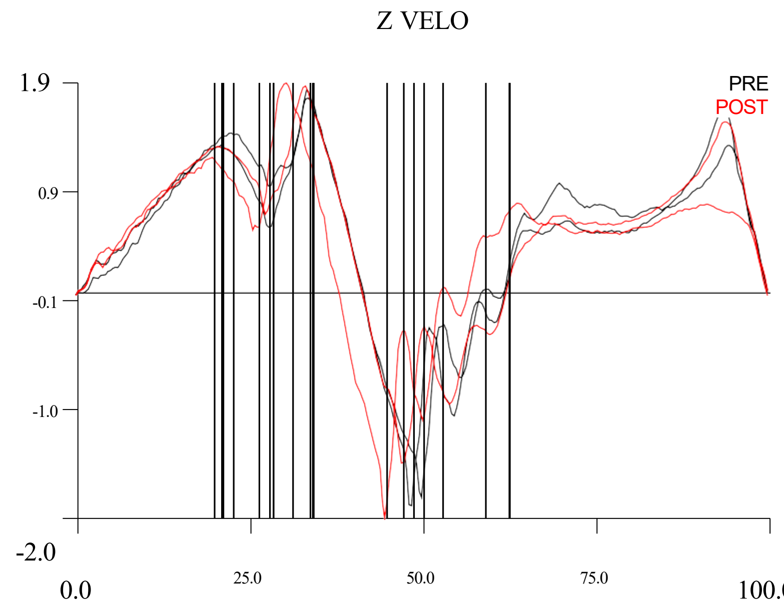


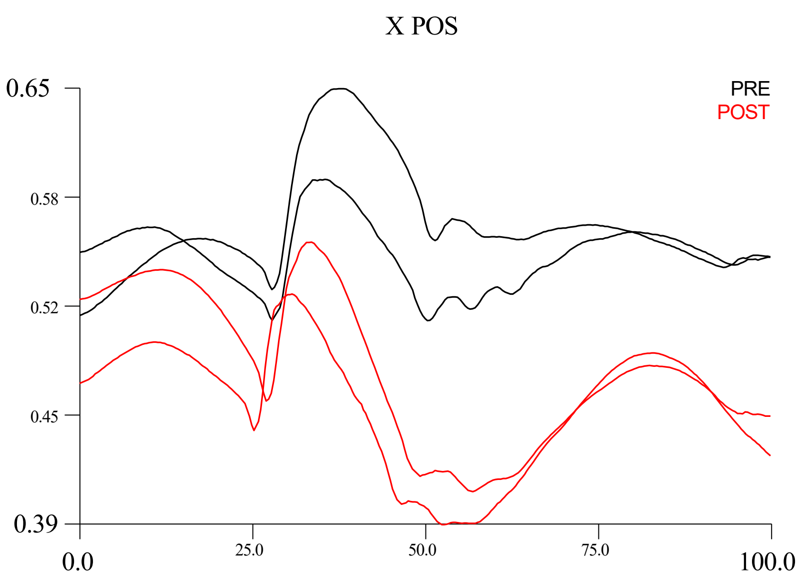
PRE VS POST METRICS

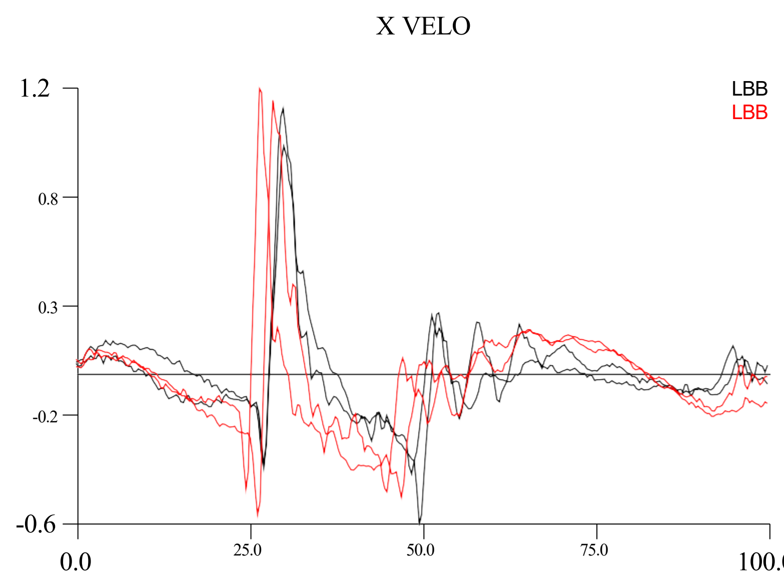
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.768	1.304	1.097	1.175	-1.658	0.110	0.200	0.380	1.560
HP POST	1.834	1.321	1.043	1.201	-1.532	0.810	0.160	0.410	1.610
PC PRE	1.794	1.336	1.132	1.221	-1.801	0.090	0.230	0.370	2.880
PC POST	1.738	1.292	0.961	1.168	-1.710	0.100	0.100	0.450	1.800

Potentiation Report

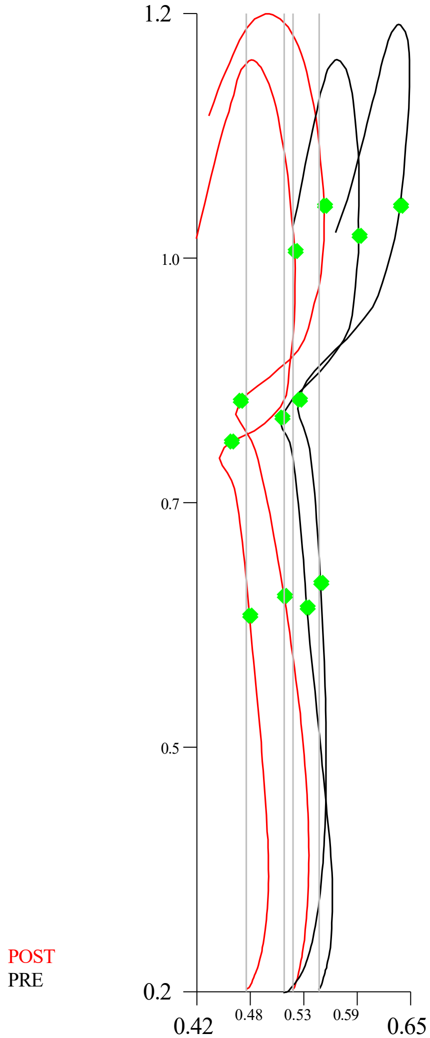


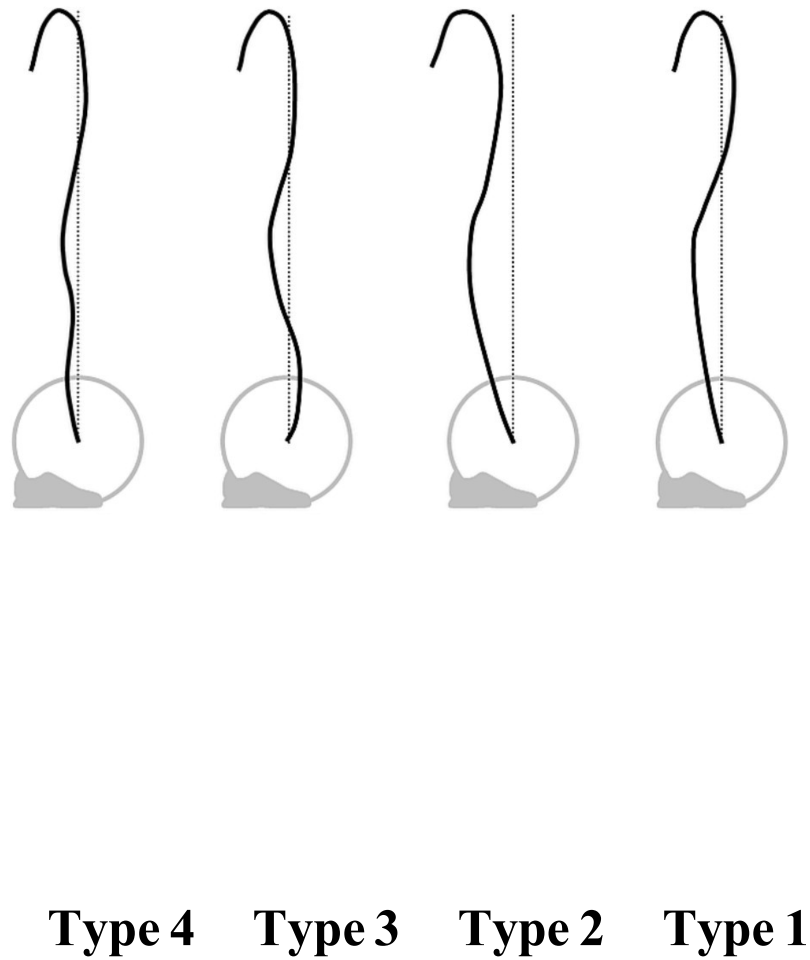






Barbell Trajectory



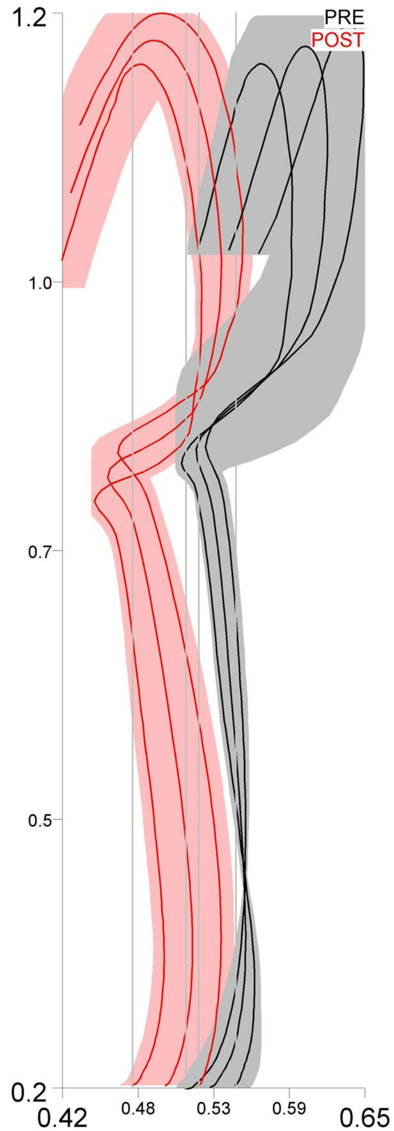


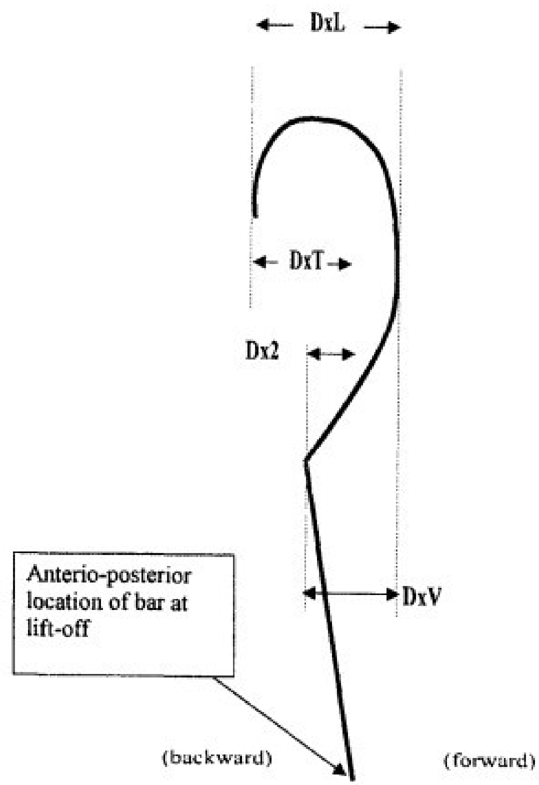
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.789 ; 1.719	1.183 ; 1.220	0.996 ; 1.028	1.007 ; 1.000	-2.020 ; -1.860	0.580 ; 0.630	0.160 ; 0.160	0.400 ; 0.450	1.040 ; 1.150
POST	1.852 ; 1.825	1.182 ; 1.231	0.980 ; 1.028	0.993 ; 1.123	-1.896 ; -1.755	0.610 ; 0.570	0.150 ; 0.160	0.420 ; 0.370	1.460 ; 1.030

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.070 ; -0.078	-0.105 ; -0.122
DxT: START TO CATCH	-0.027 ; 0.055	-0.052 ; -0.088
Dx2: START TO START OF 2ND PULL	-0.039 ; 0.017	-0.015 ; -0.055
DxV: 2ND PULL POSITION TO MOST FORWARD	0.082 ; 0.117	0.068 ; 0.089





LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

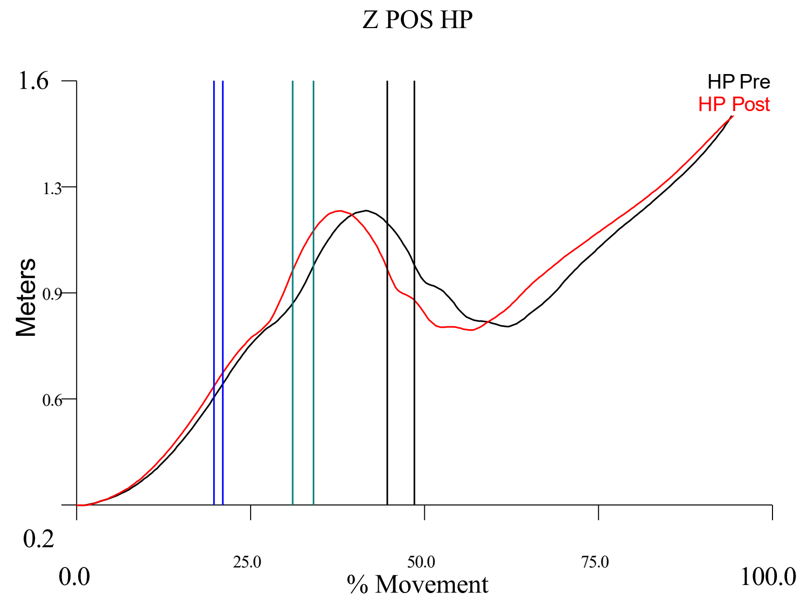
DxL = most forward position to catch

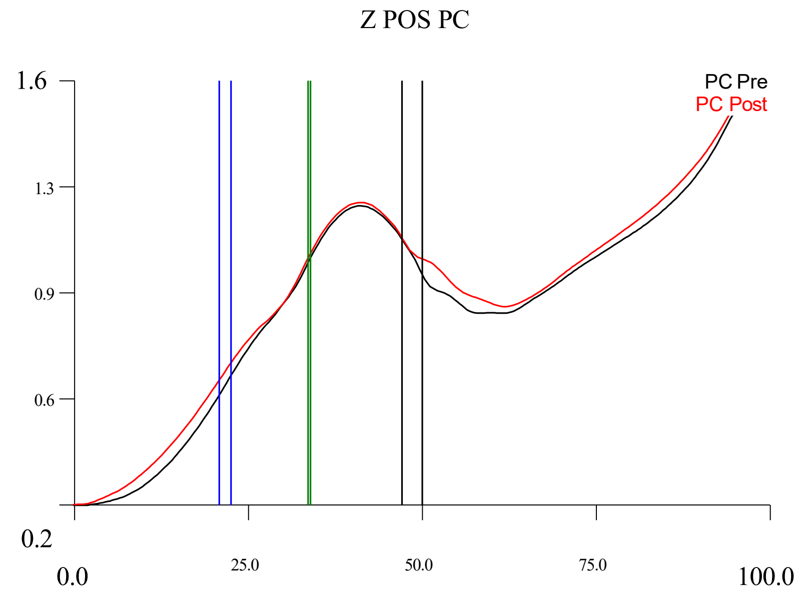
DxT = start position to catch position

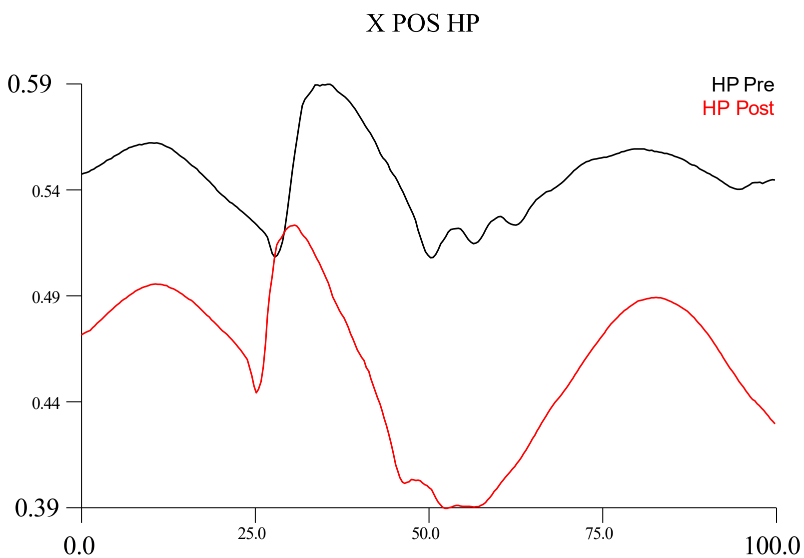
Dx2 = start position to beginning of 2nd pull

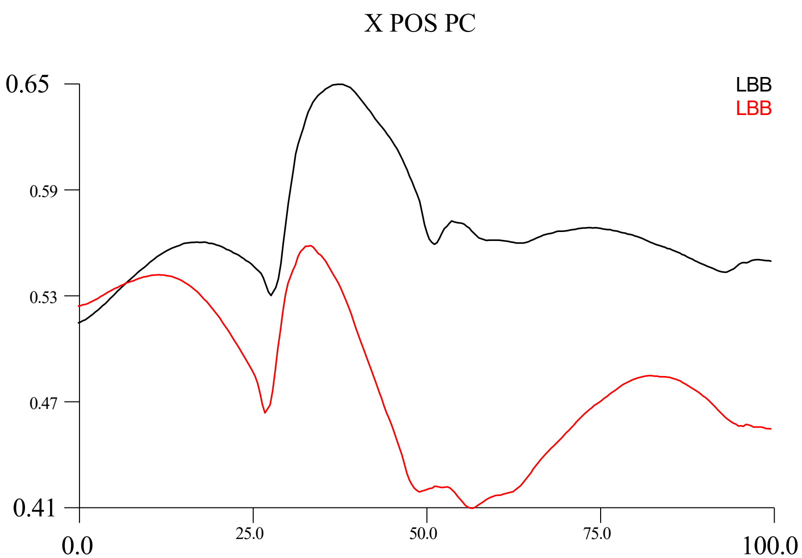
DxV = 2nd pull position to most forward position

ATHLETE Report



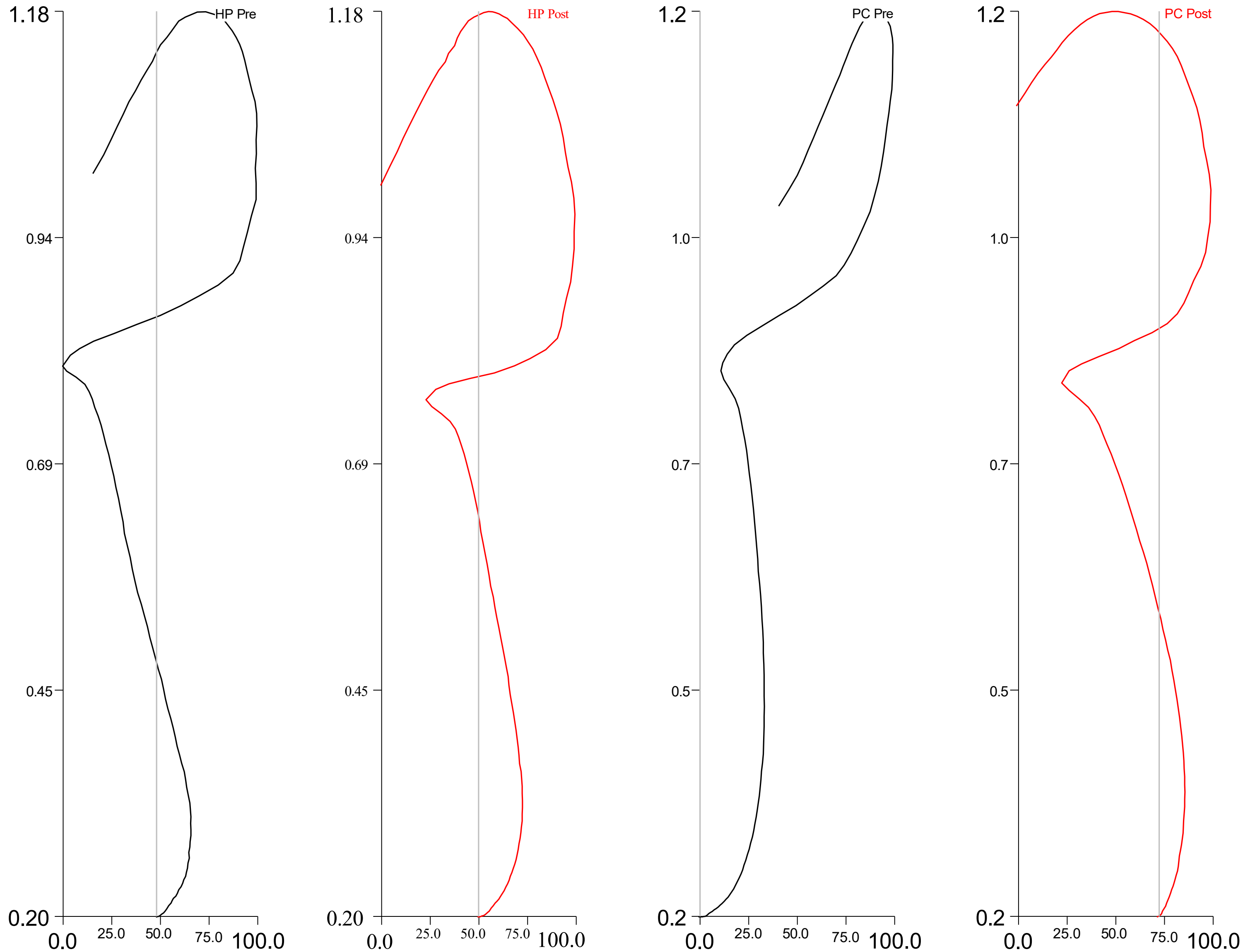






ANTERIOR POSTERIOR CHANGES HP VS PC

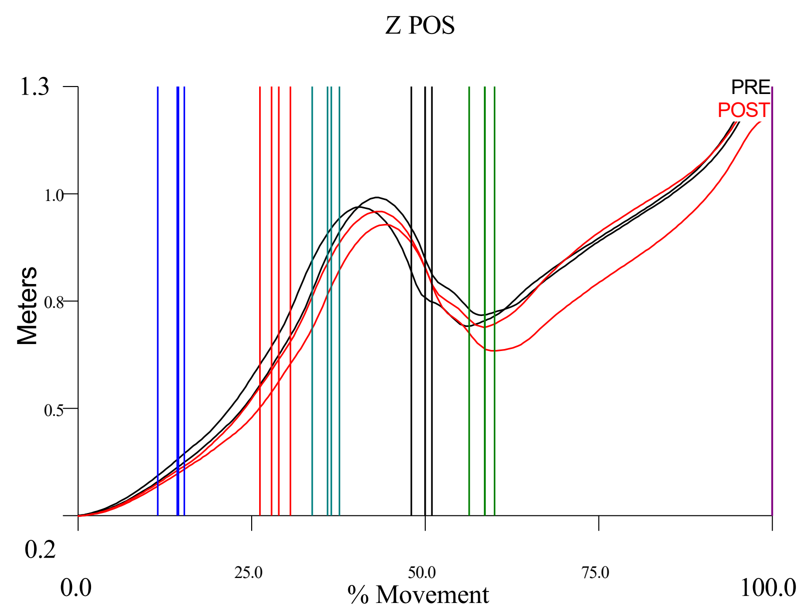
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.070	-0.105	-0.078	-0.122
DxT: START TO CATCH	-0.027	-0.052	0.055	-0.088
Dx2: START TO START OF 2ND PULL	-0.039	-0.015	0.017	-0.055
DxV: 2ND PULL POSITION TO MOST FORWARD	0.082	0.068	0.117	0.089

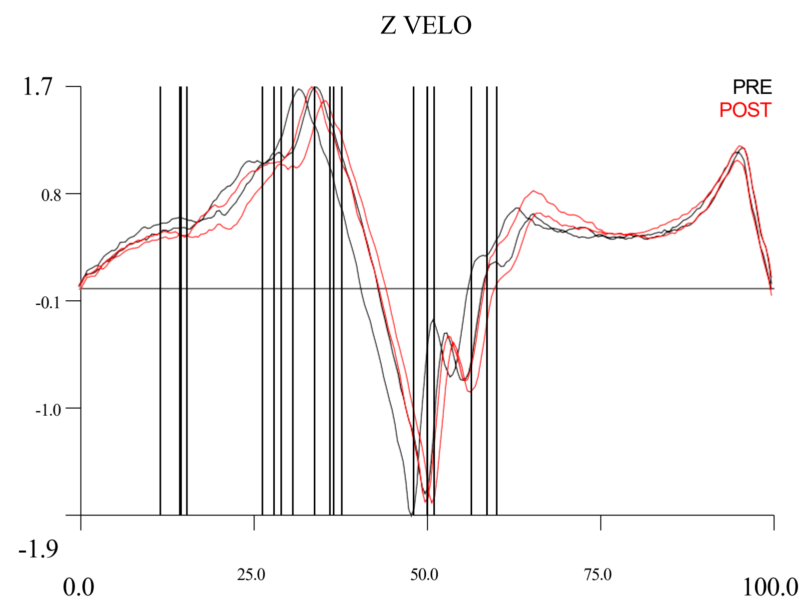


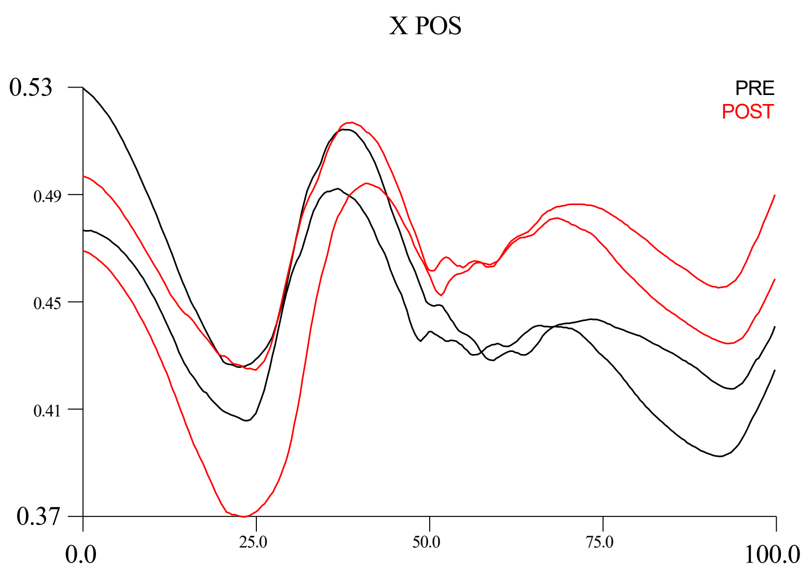
PRE VS POST METRICS

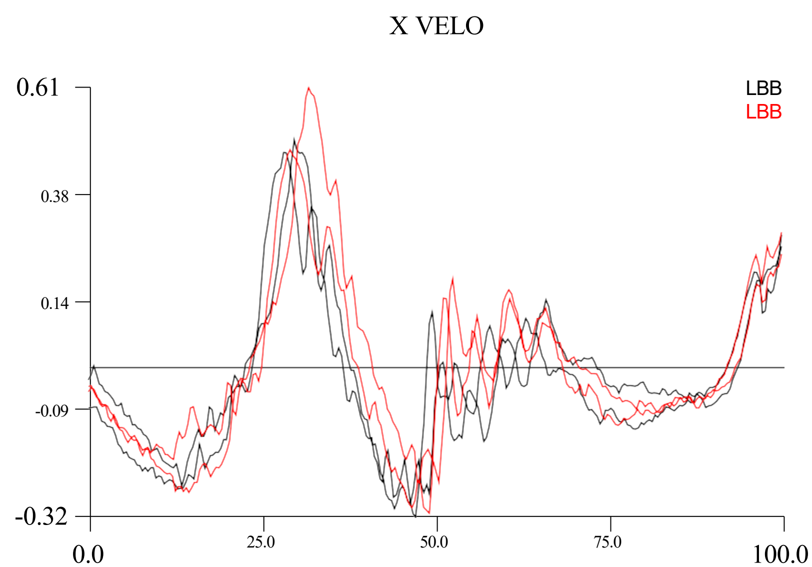
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.789	1.183	0.996	1.007	-2.020	0.580	0.160	0.400	1.040
HP POST	1.852	1.182	0.980	0.993	-1.896	0.610	0.150	0.420	1.460
PC PRE	1.719	1.220	1.028	1.000	-1.860	0.630	0.160	0.450	1.150
PC POST	1.825	1.231	1.028	1.123	-1.755	0.570	0.160	0.370	1.030

Potentiation Report

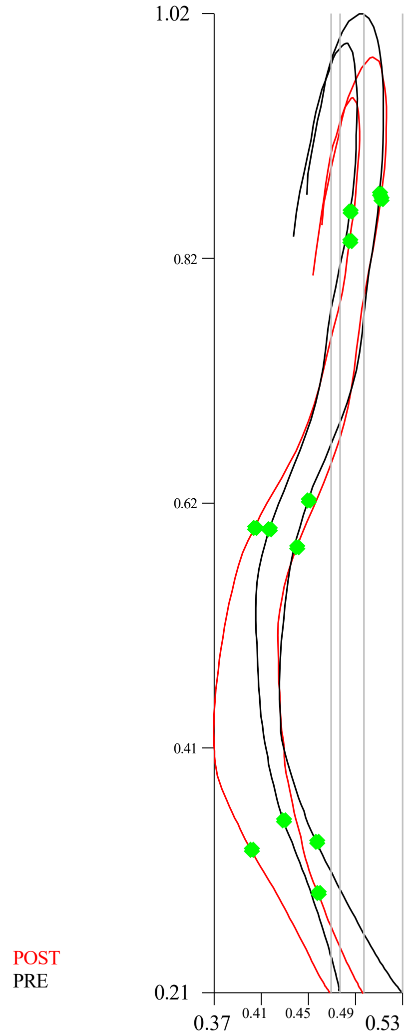


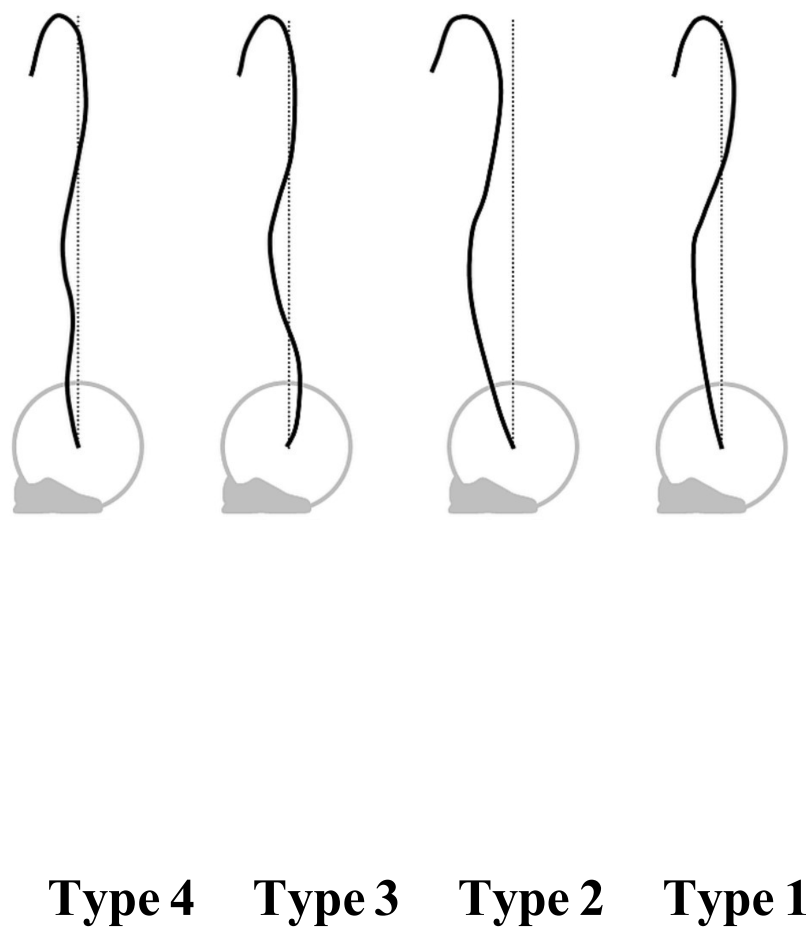






Barbell Trajectory



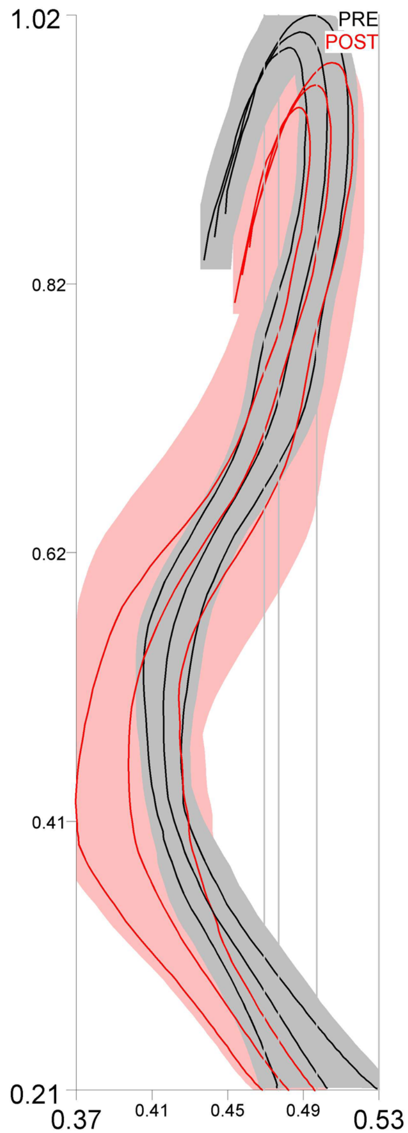


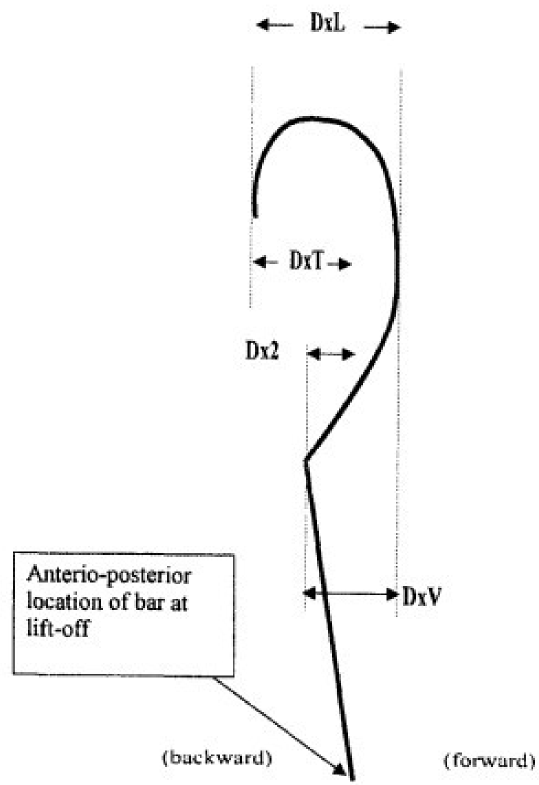
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.704 ; 1.690	1.020 ; 0.996	0.872 ; 0.857	0.871 ; 0.836		0.370 ; 0.360	0.180 ; 0.190	0.360 ; 0.360	1.060 ; 1.100
POST	1.589 ; 1.708	0.951 ; 0.984	0.833 ; 0.867	0.804 ; 0.846		0.390 ; 0.280	0.180 ; 0.210	0.340 ; 0.330	1.020 ; 1.010

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.063 ; -0.053	-0.039 ; -0.053
DxT: START TO CATCH	-0.078 ; -0.038	-0.014 ; -0.034
Dx2: START TO START OF 2ND PULL	-0.077 ; -0.058	-0.063 ; -0.055
DxV: 2ND PULL POSITION TO MOST FORWARD	0.062 ; 0.073	0.087 ; 0.074





LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

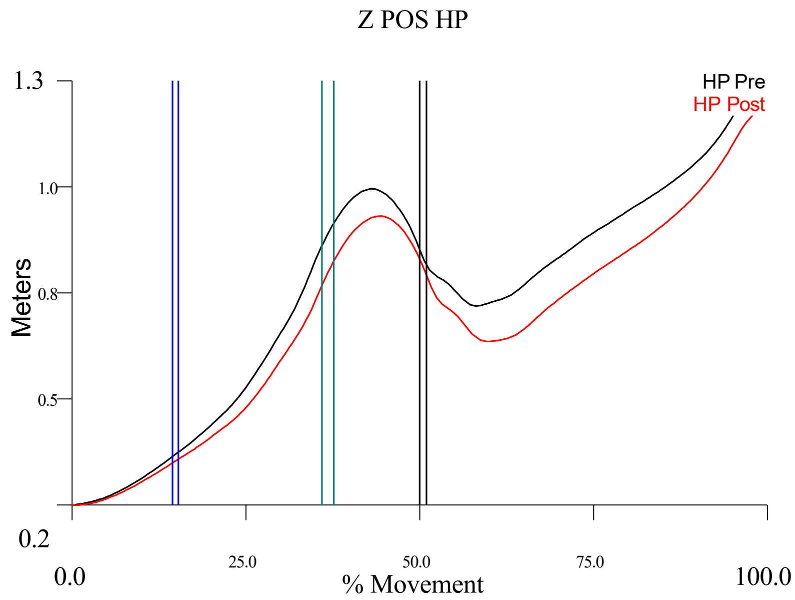
DxL = most forward position to catch

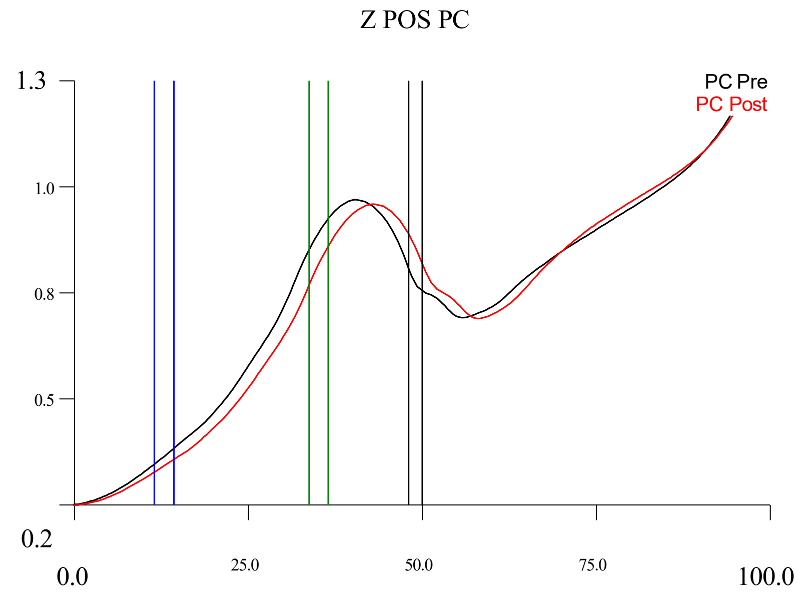
DxT = start position to catch position

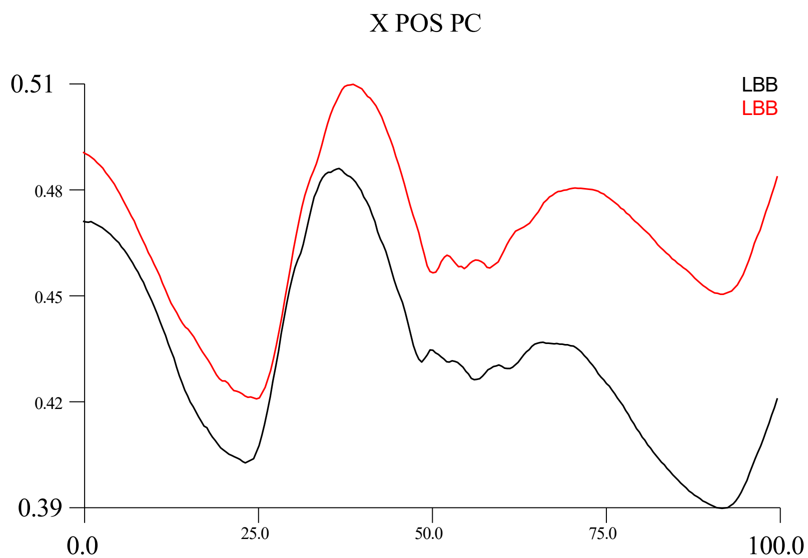
Dx2 = start position to beginning of 2nd pull

DxV = 2nd pull position to most forward position

ATHLETE Report

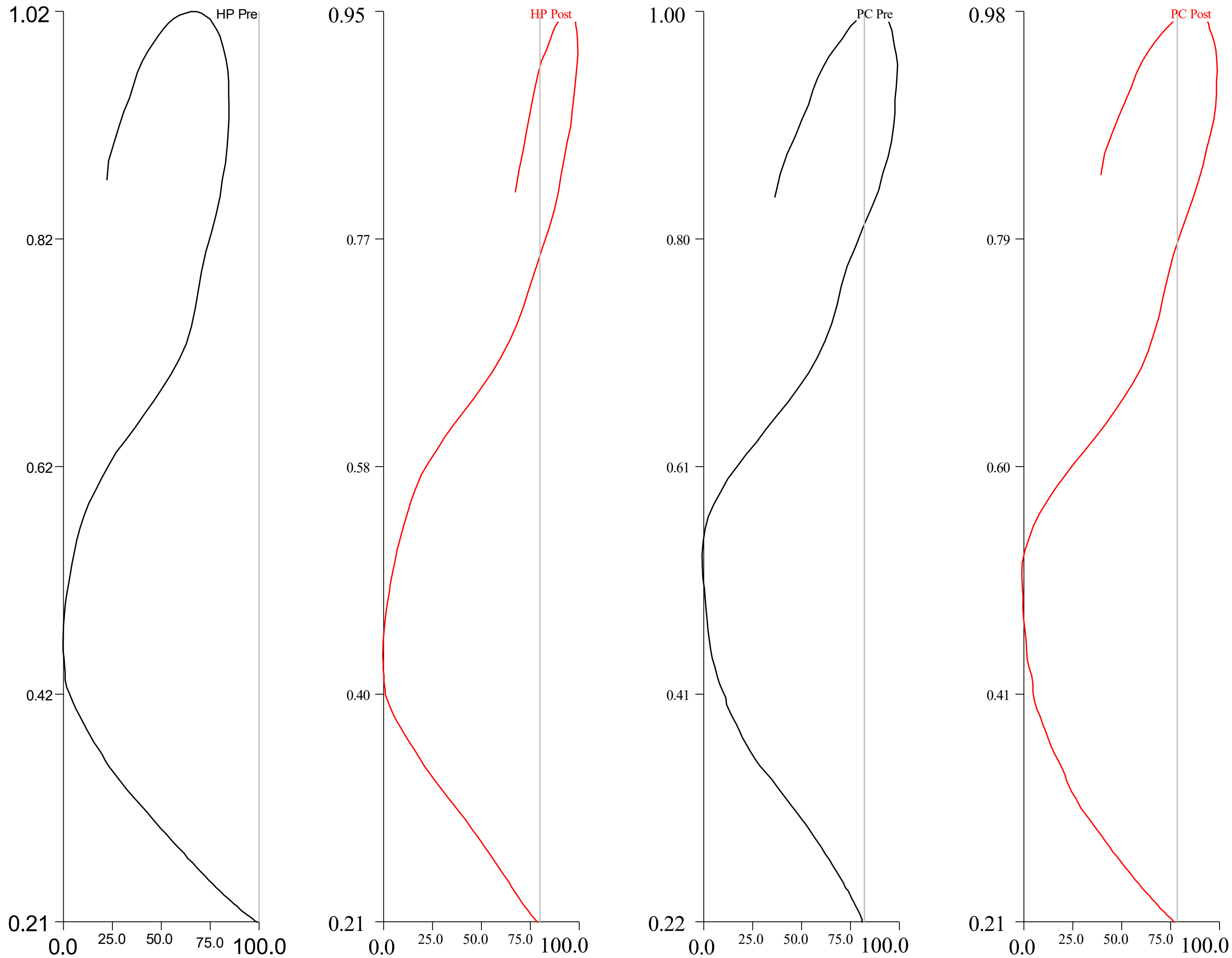






ANTERIOR POSTERIOR CHANGES HP VS PC

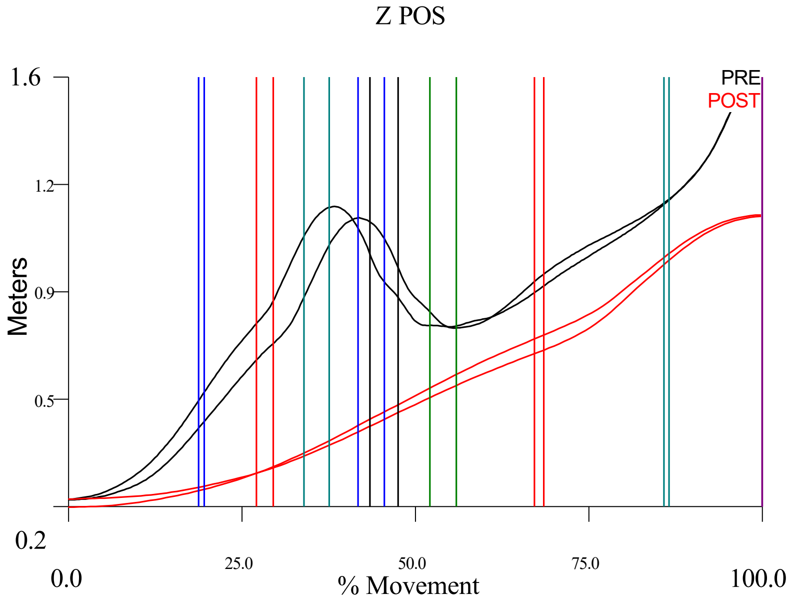
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.063	-0.039	-0.053	-0.053
DxT: START TO CATCH	-0.078	-0.014	-0.038	-0.034
Dx2: START TO START OF 2ND PULL	-0.077	-0.063	-0.058	-0.055
DxV: 2ND PULL POSITION TO MOST FORWARD	0.062	0.087	0.073	0.074

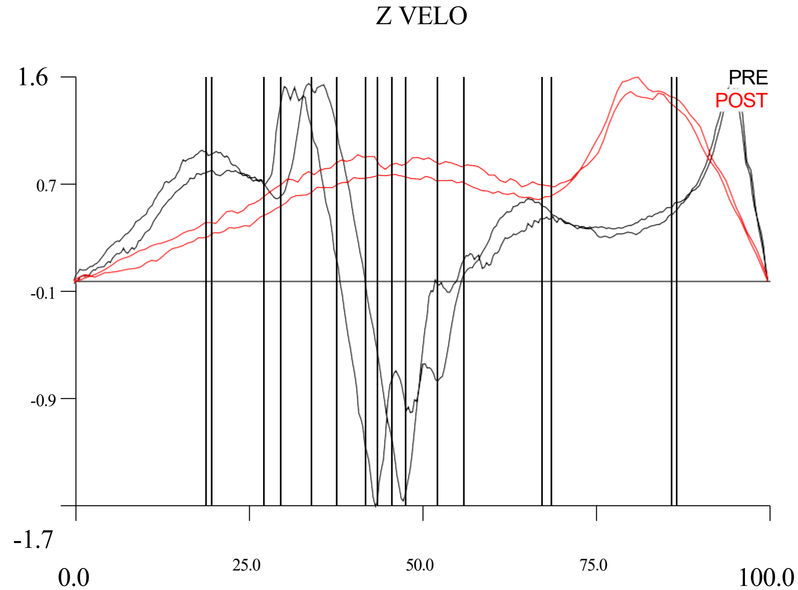


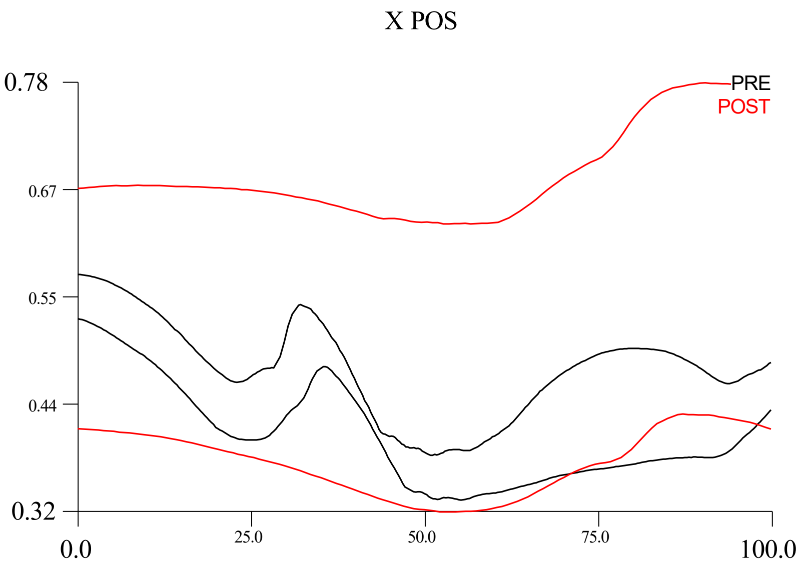
PRE VS POST METRICS

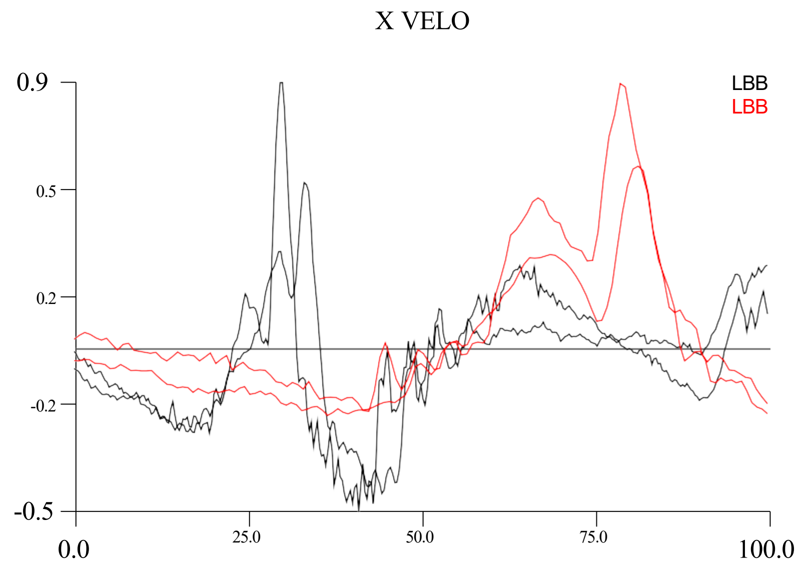
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.704	1.020	0.872	0.871		0.370	0.180	0.360	1.060
HP POST	1.589	0.951	0.833	0.804		0.390	0.180	0.340	1.020
PC PRE	1.690	0.996	0.857	0.836		0.360	0.190	0.360	1.100
PC POST	1.708	0.984	0.867	0.846		0.280	0.210	0.330	1.010

Potentiation Report

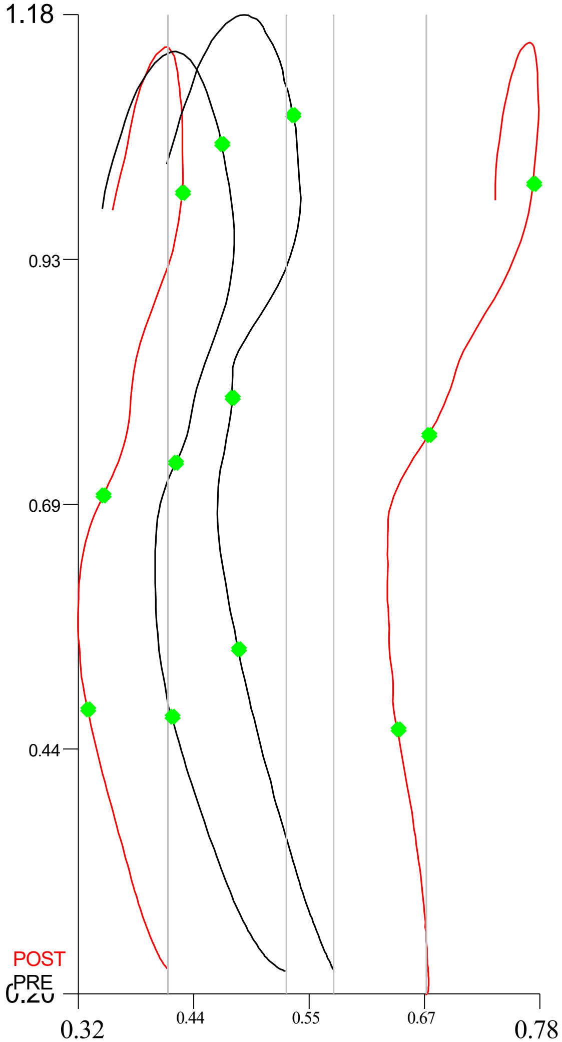


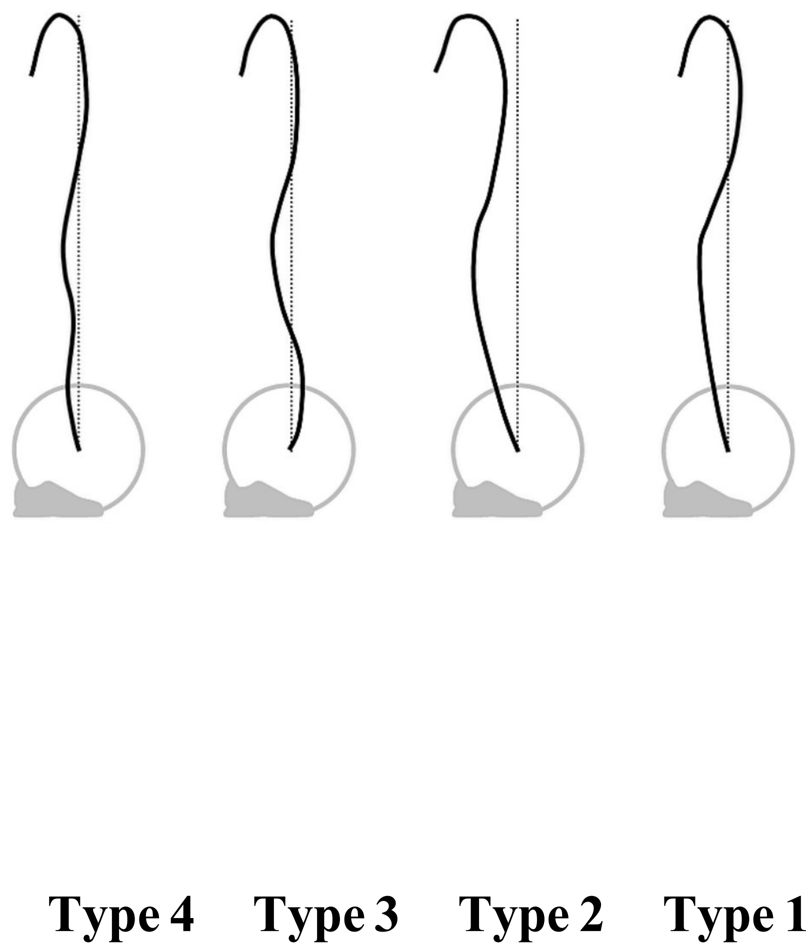






Barbell Trajectory



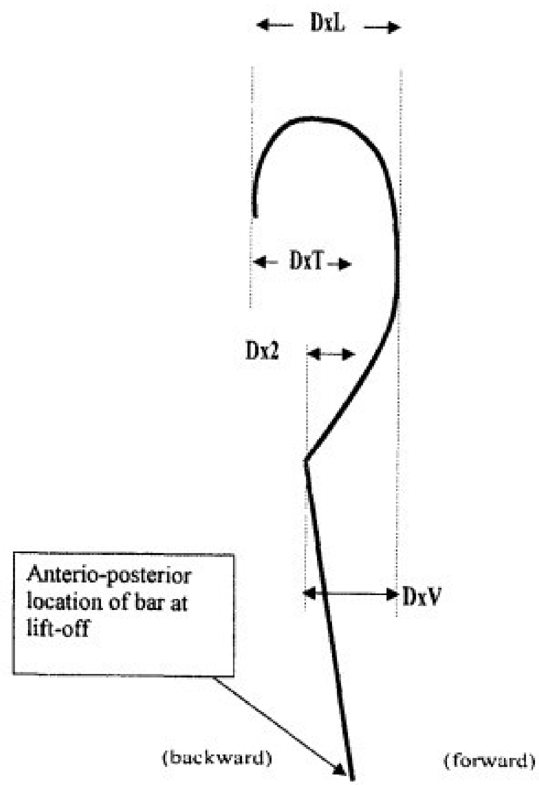


PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.504 ; 1.527	1.178 ; 1.142	1.078 ; 1.049	1.029 ; 0.984	-1.972 ; -2.035	0.630 ; 0.630	0.230 ; 0.260	0.320 ; 0.320	1.610 ; 1.420
POST	1.464 ; 1.576	1.150 ; 1.146	1.009 ; 1.000	0.993 ; 0.983		0.530 ; 0.610	0.220 ; 0.260	0.360 ; 0.360	

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.134 ; -0.132	
DxT: START TO CATCH	-0.166 ; -0.183	0.070 ; -0.055
Dx2: START TO START OF 2ND PULL	-0.101 ; -0.110	0.003 ; -0.064
DxV: 2ND PULL POSITION TO MOST FORWARD	0.069 ; 0.059	



LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

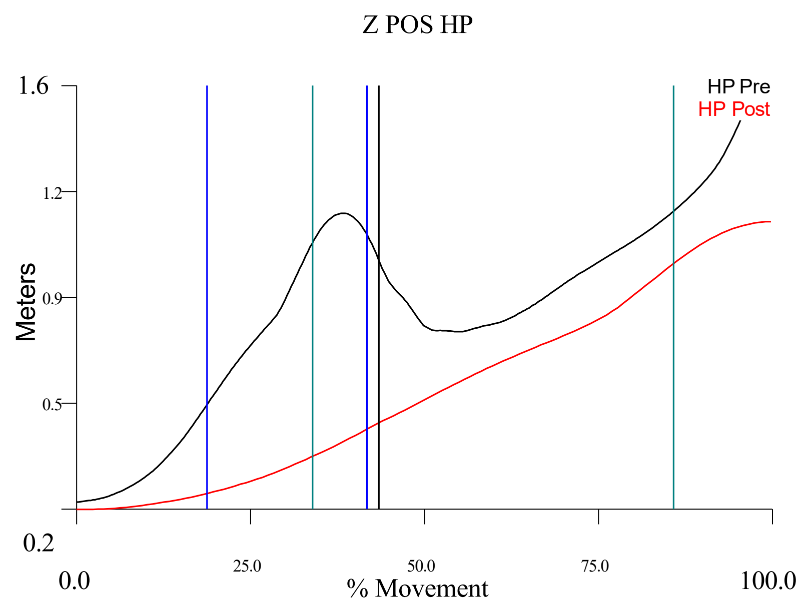
DxL = most forward position to catch

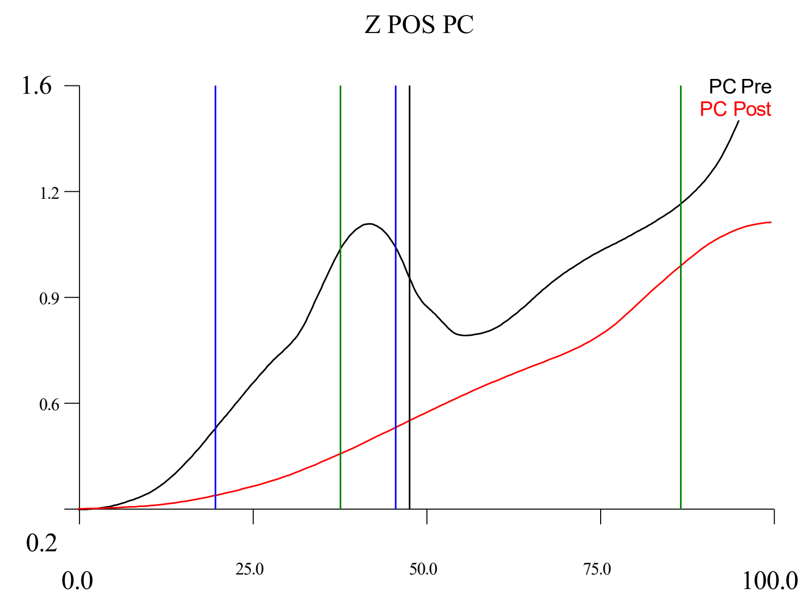
DxT = start position to catch position

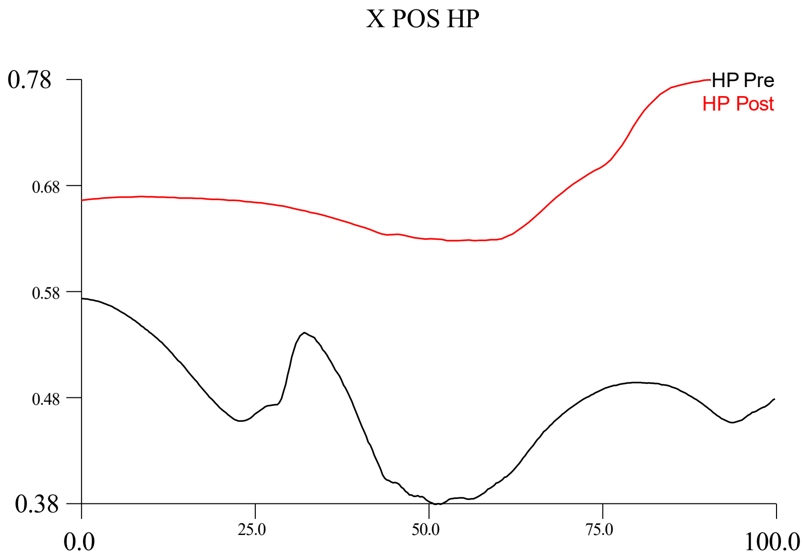
Dx2 = start position to beginning of 2nd pull

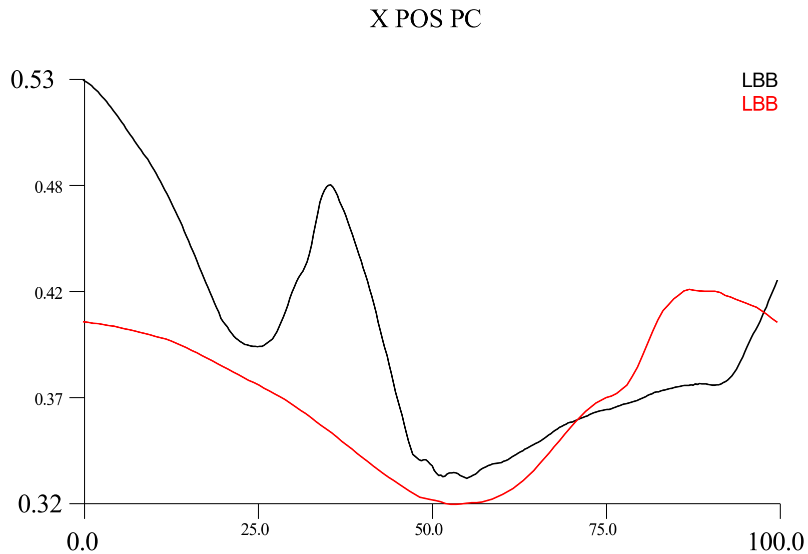
DxV = 2nd pull position to most forward position

ATHLETE Report



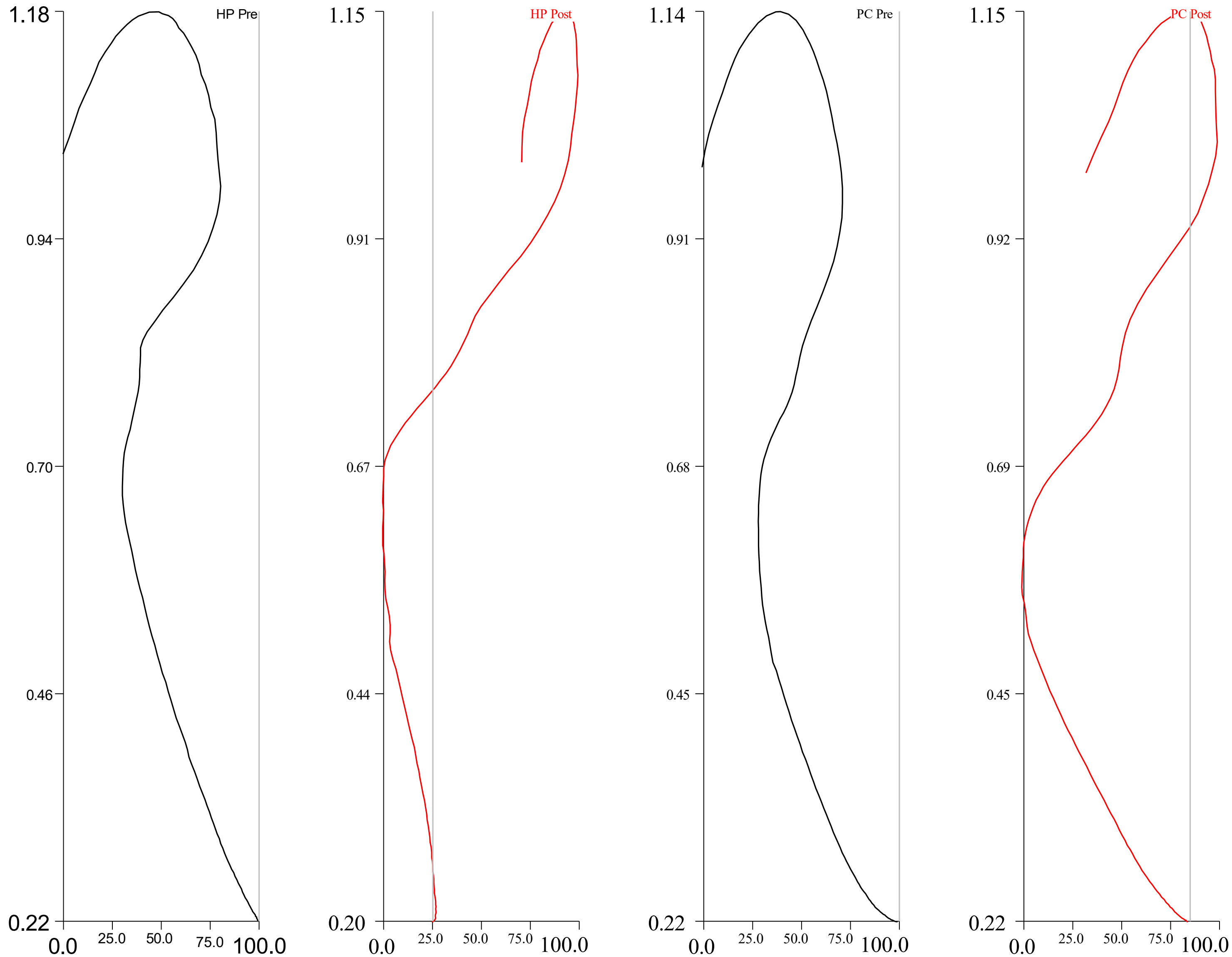






ANTERIOR POSTERIOR CHANGES HP VS PC

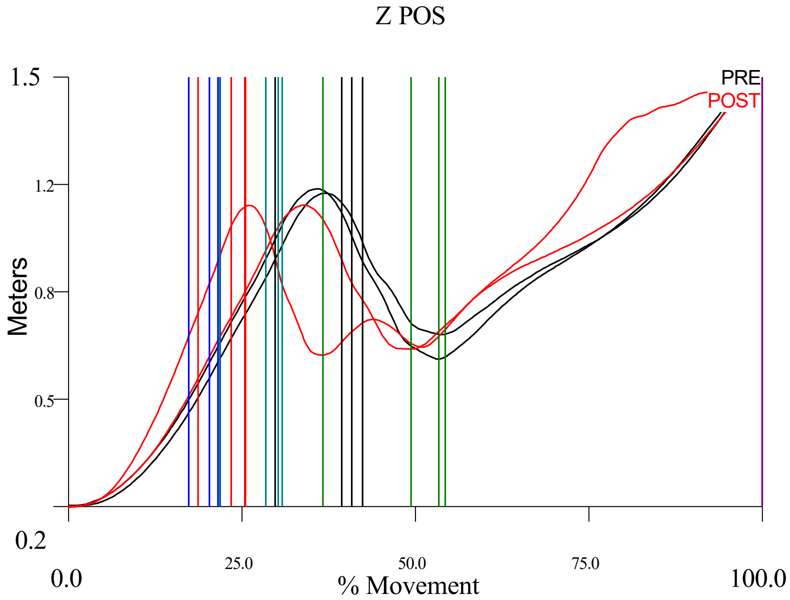
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.134		-0.132	
DxT: START TO CATCH	-0.166	0.070	-0.183	-0.055
Dx2: START TO START OF 2ND PULL	-0.101	0.003	-0.110	-0.064
DxV: 2ND PULL POSITION TO MOST FORWARD	0.069		0.059	

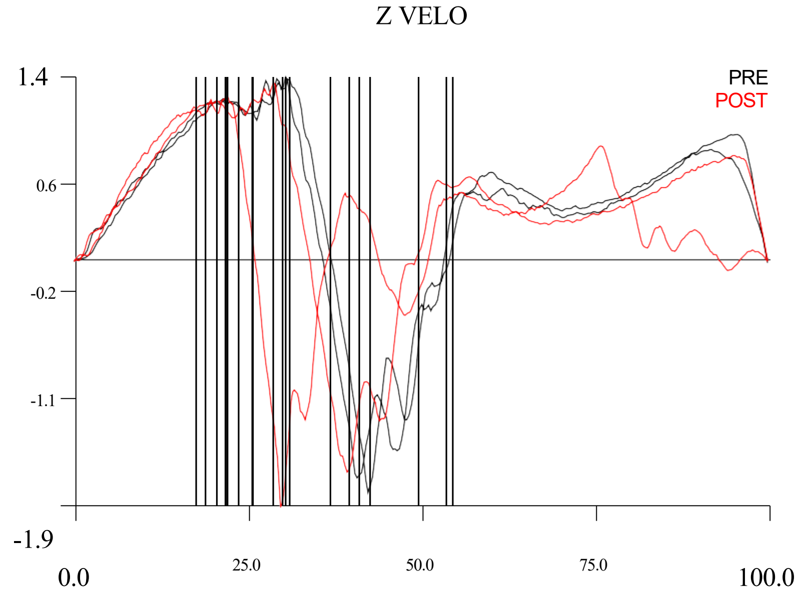


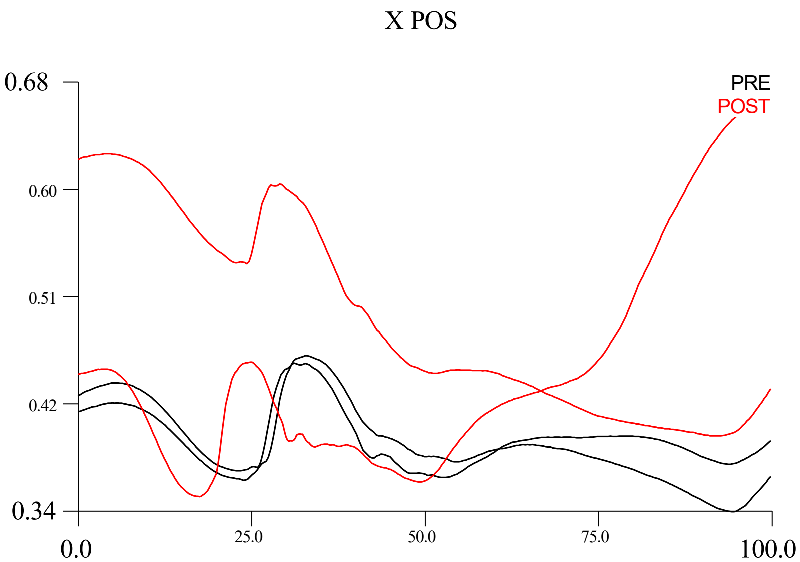
PRE VS POST METRICS

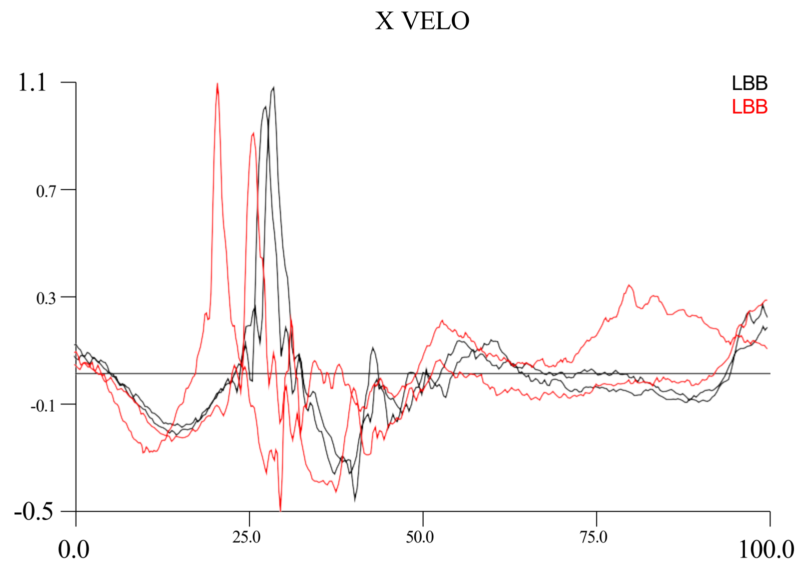
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.504	1.178	1.078	1.029	-1.972	0.630	0.230	0.320	1.610
HP POST	1.464	1.150	1.009	0.993		0.530	0.220	0.360	
PC PRE	1.527	1.142	1.049	0.984	-2.035	0.630	0.260	0.320	1.420
PC POST	1.576	1.146	1.000	0.983		0.610	0.260	0.360	

Potentiation Report

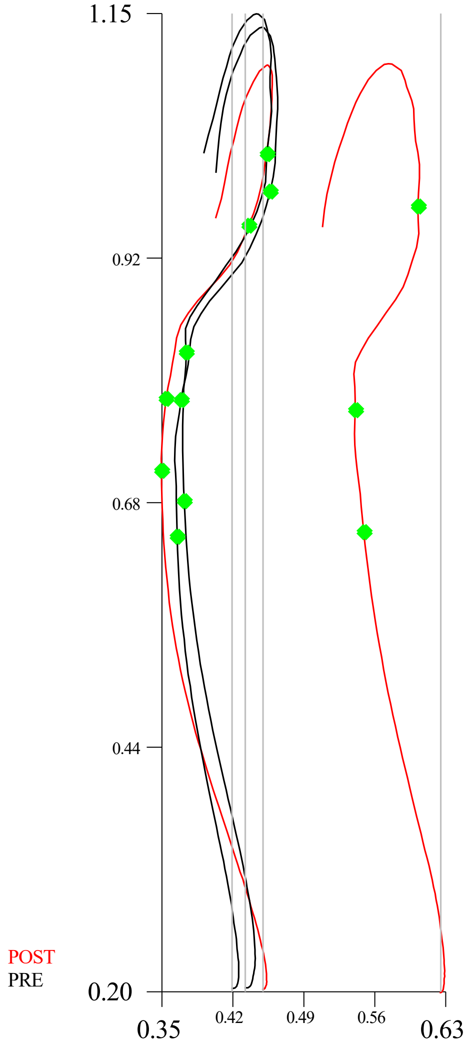


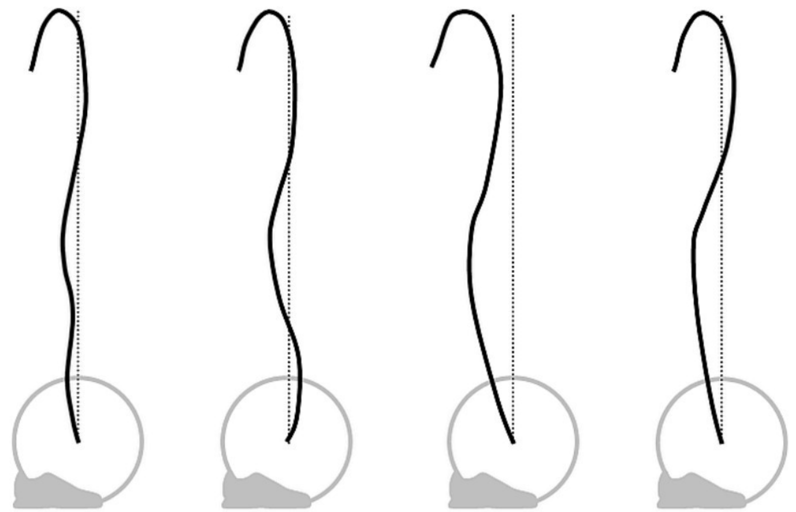






Barbell Trajectory





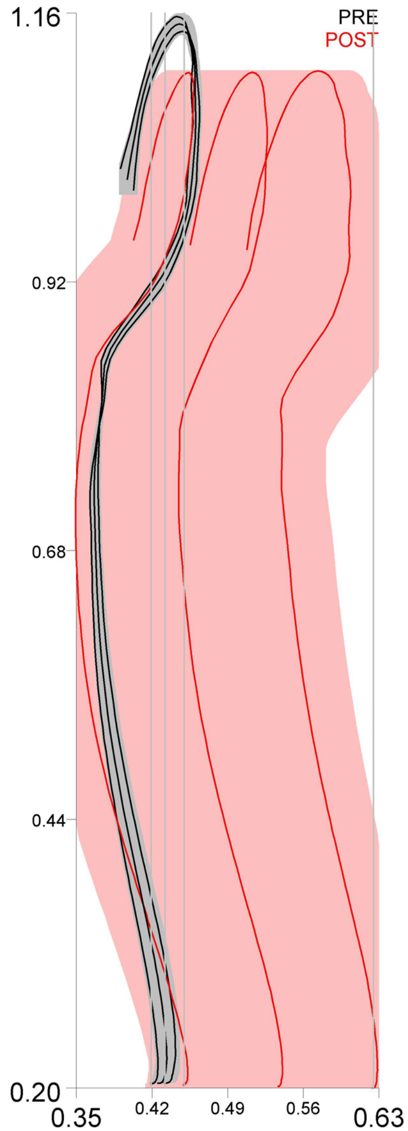
Type 4 **Type 3** **Type 2** **Type 1**

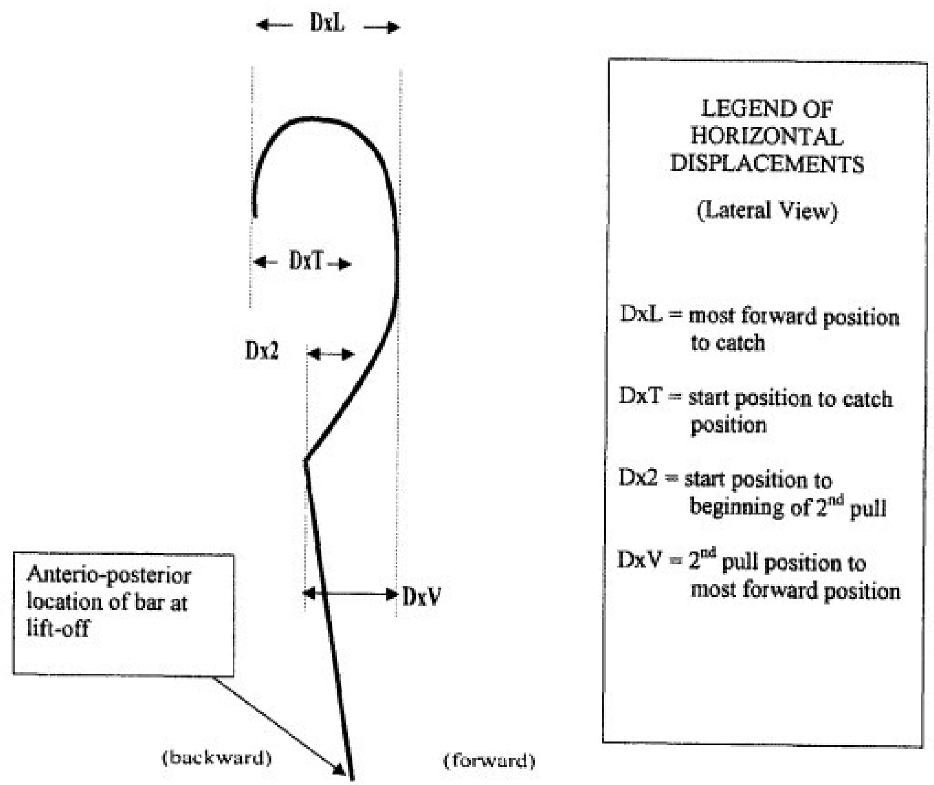
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.430 ; 1.426	1.154 ; 1.141	1.017 ; 0.980	1.018 ; 0.999	-2.229 ; -2.116	0.670 ; 0.660	0.150 ; 0.160	0.330 ; 0.350	1.450 ; 1.380
POST	1.349 ; 1.272	1.105 ; 1.104	0.966 ; 0.947	0.946 ; 0.955	-1.897 ; -2.241	0.650 ; 0.780	0.160 ; 0.140	0.350 ; 0.360	1.620 ; 2.850

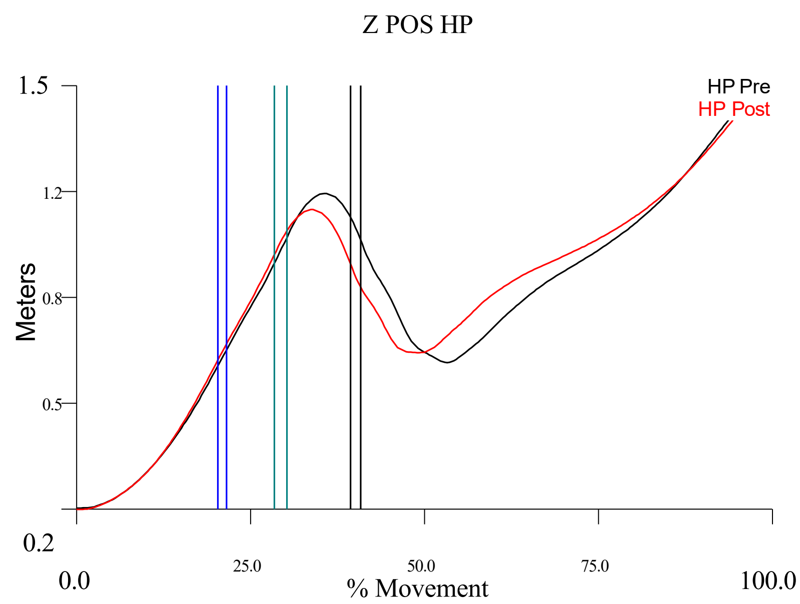
ANTERIOR POSTERIOR CHANGES

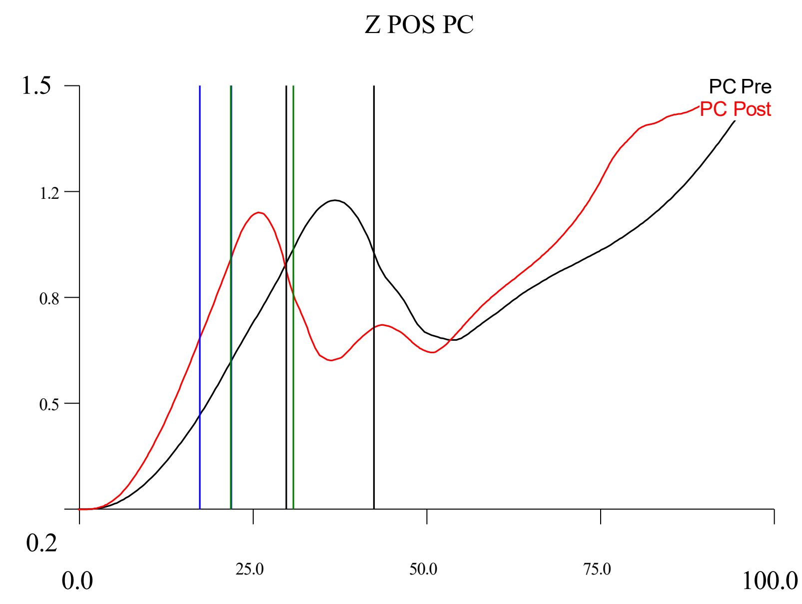
	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.066 ; -0.060	-0.095 ; -0.055
DxT: START TO CATCH	-0.040 ; -0.015	-0.114 ; -0.045
Dx2: START TO START OF 2ND PULL	-0.057 ; -0.049	-0.082 ; -0.094
DxV: 2ND PULL POSITION TO MOST FORWARD	0.083 ; 0.094	0.063 ; 0.104

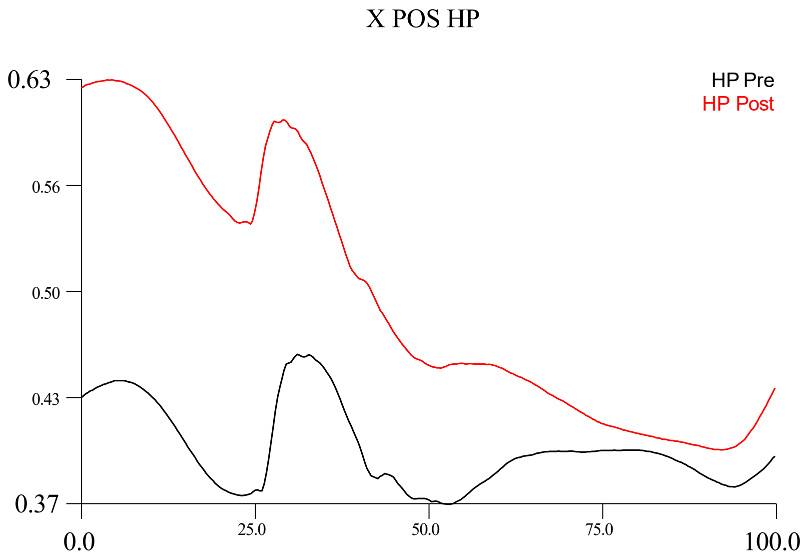


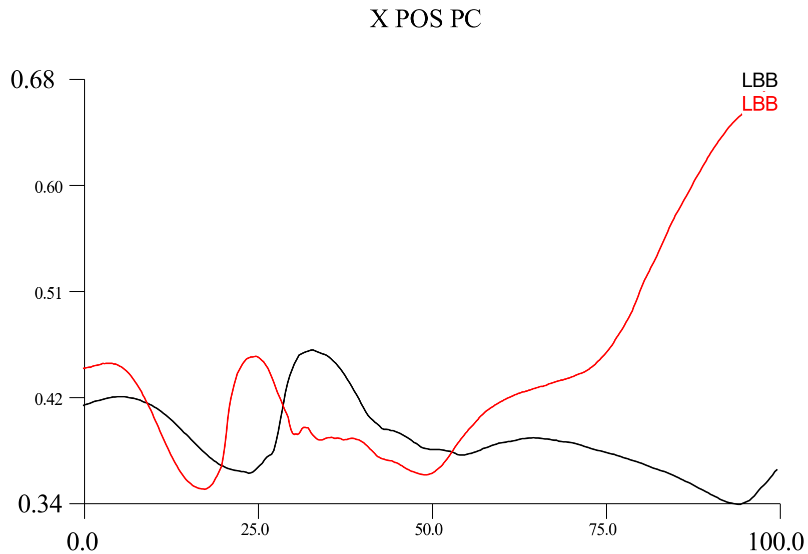


ATHLETE Report



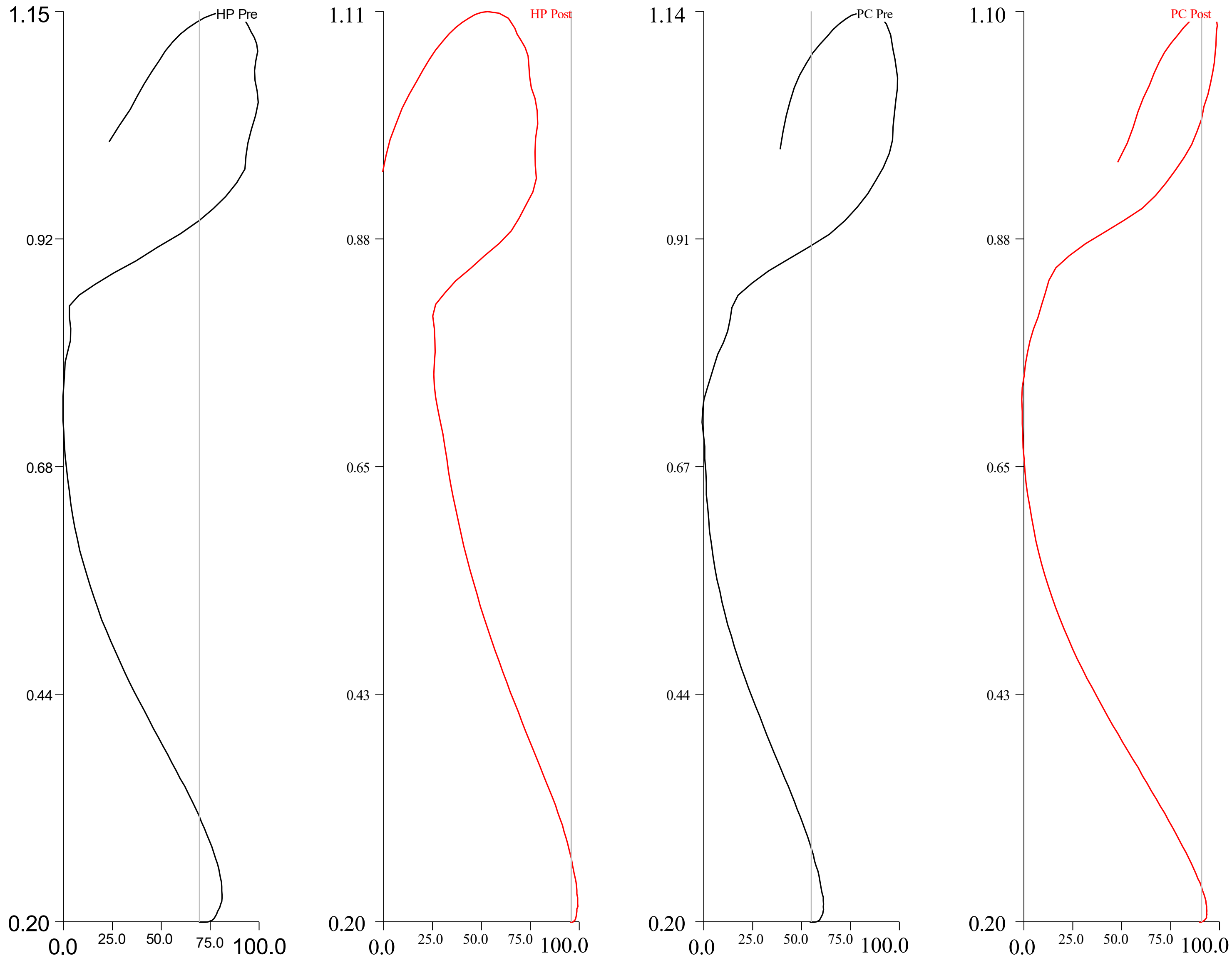






ANTERIOR POSTERIOR CHANGES HP VS PC

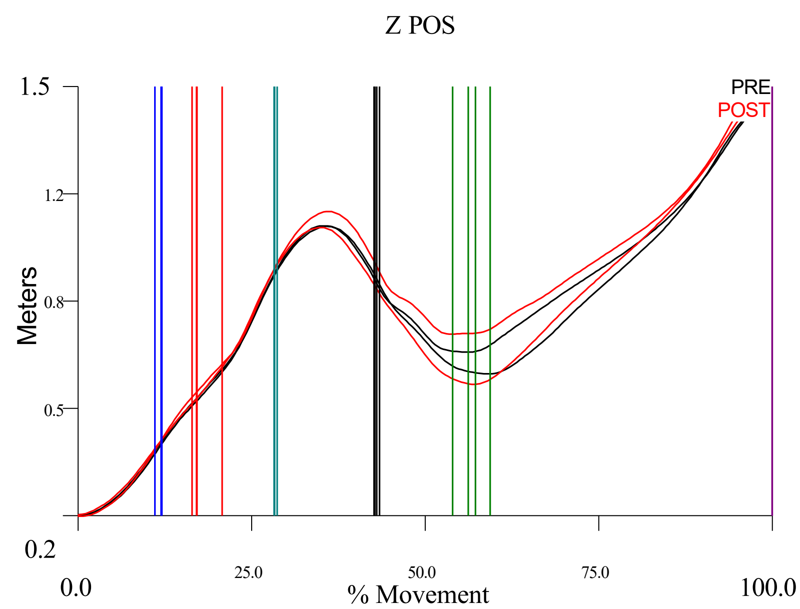
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.066	-0.095	-0.060	-0.055
DxT: START TO CATCH	-0.040	-0.114	-0.015	-0.045
Dx2: START TO START OF 2ND PULL	-0.057	-0.082	-0.049	-0.094
DxV: 2ND PULL POSITION TO MOST FORWARD	0.083	0.063	0.094	0.104

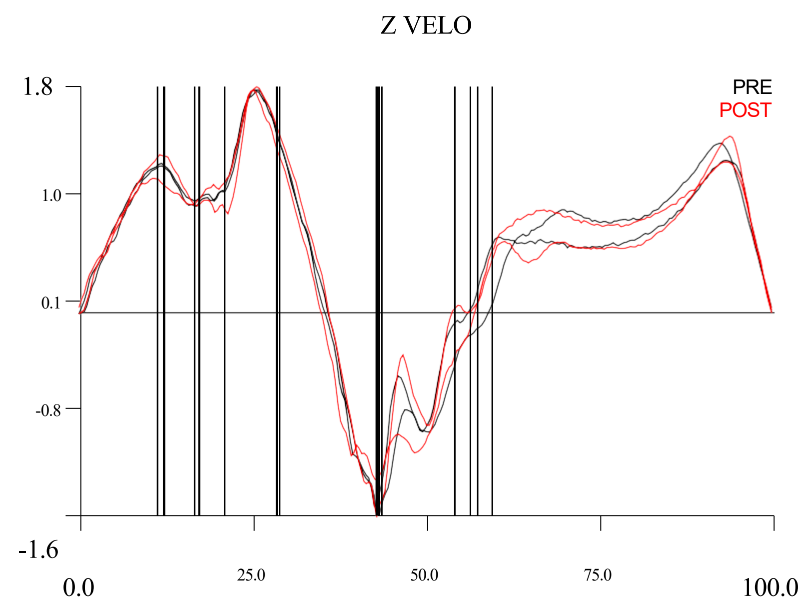


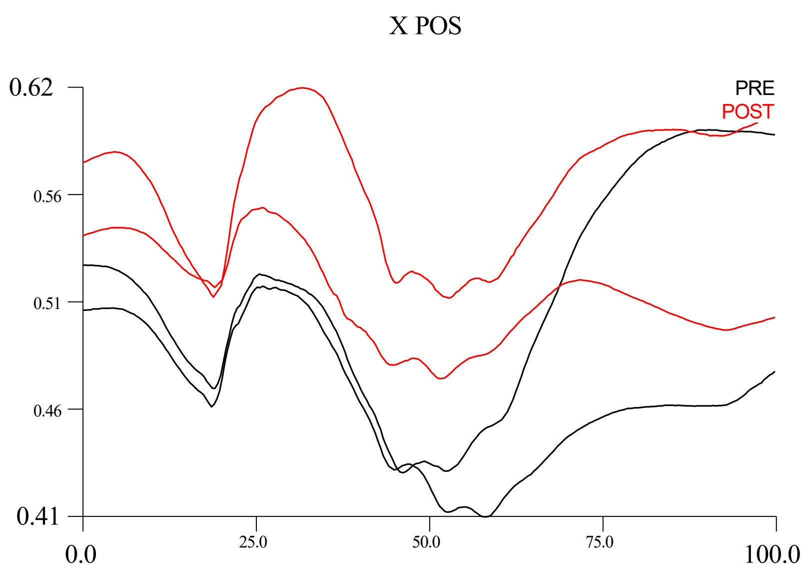
PRE VS POST METRICS

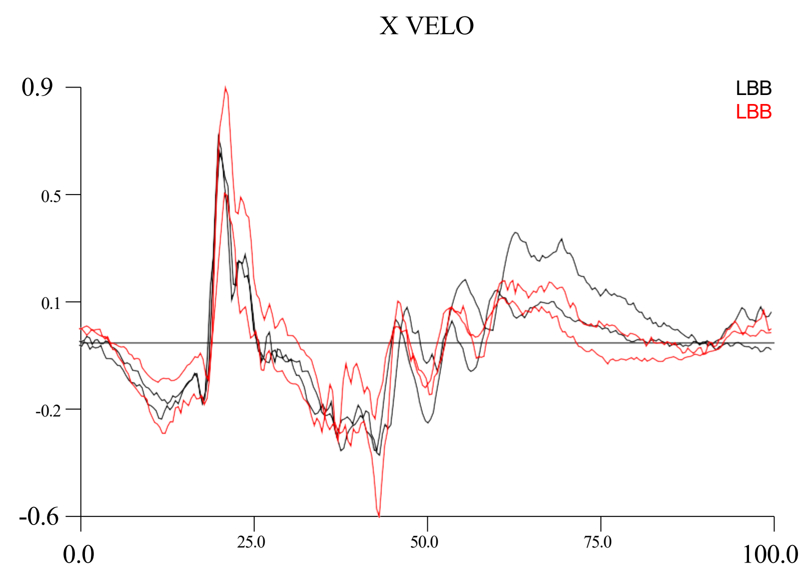
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.430	1.154	1.017	1.018	-2.229	0.670	0.150	0.330	1.450
HP POST	1.349	1.105	0.966	0.946	-1.897	0.650	0.160	0.350	1.620
PC PRE	1.426	1.141	0.980	0.999	-2.116	0.660	0.160	0.350	1.380
PC POST	1.272	1.104	0.947	0.955	-2.241	0.780	0.140	0.360	2.850

Potentiation Report

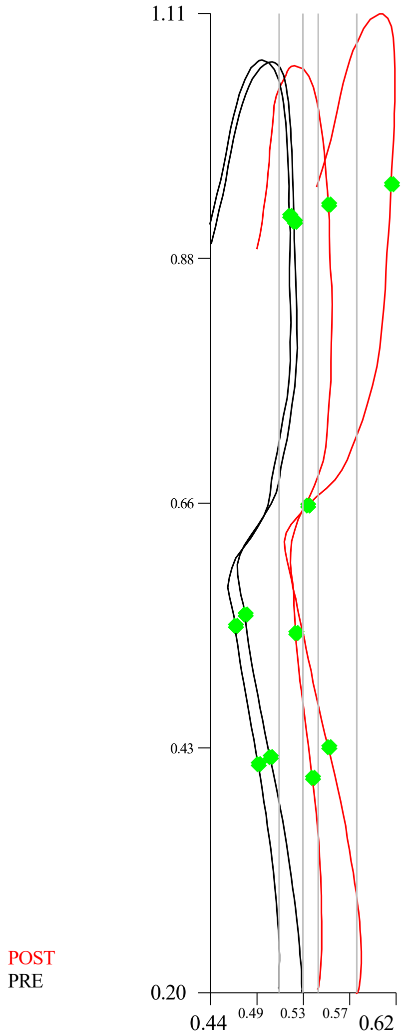


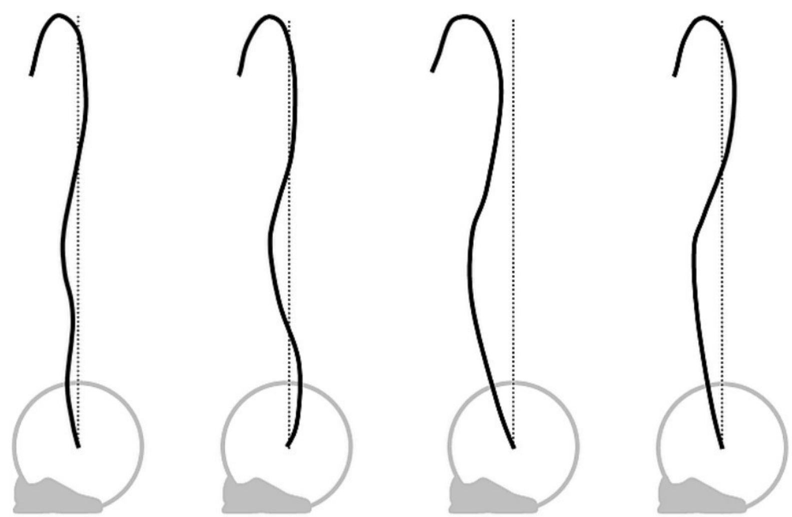






Barbell Trajectory





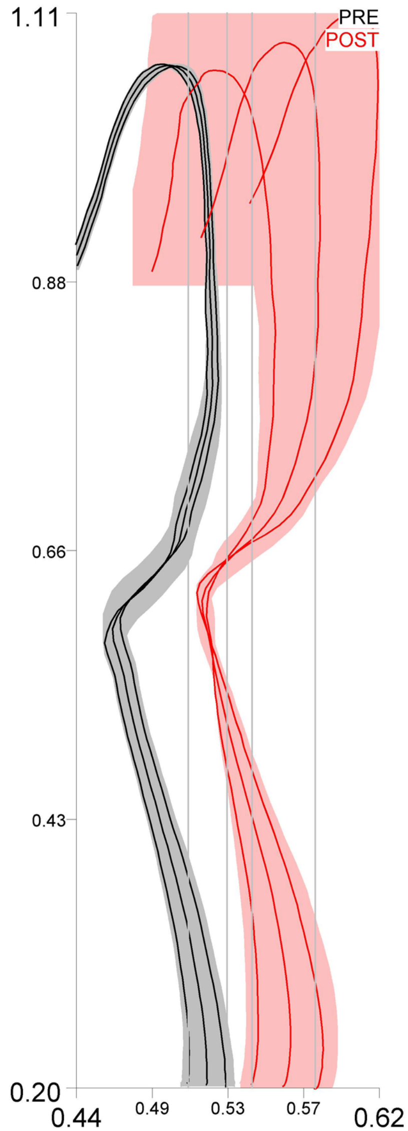
Type 4 **Type 3** **Type 2** **Type 1**

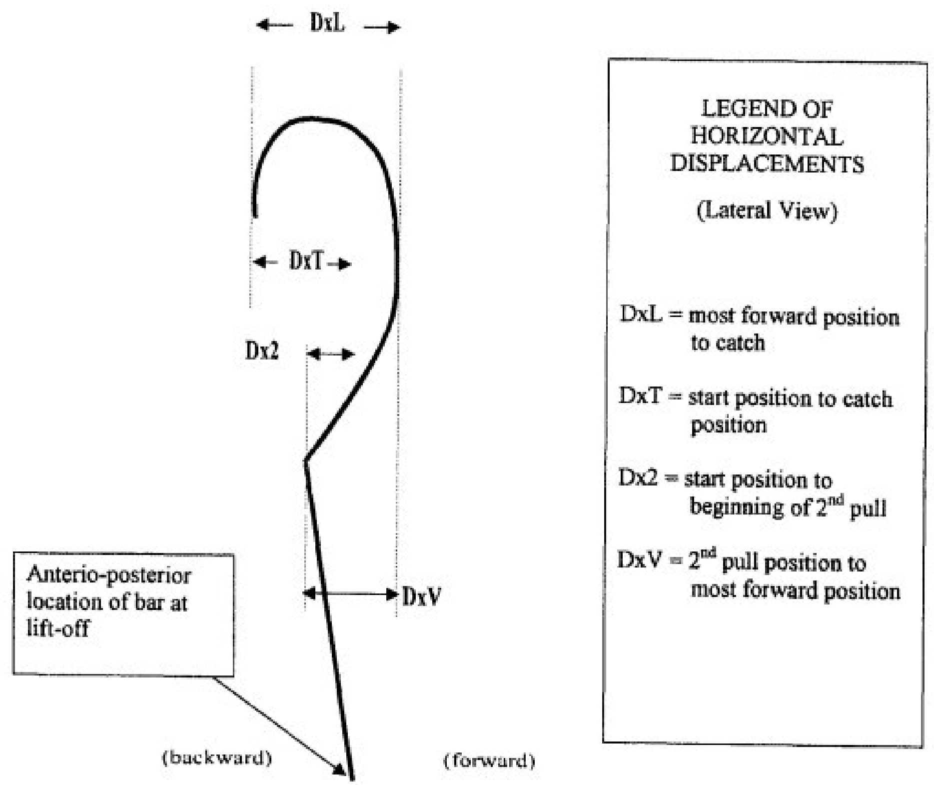
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.776 ; 1.786	1.070 ; 1.069	0.924 ; 0.919	0.917 ; 0.899		0.310 ; 0.300	0.290 ; 0.280	0.370 ; 0.380	1.130 ; 1.020
POST	1.783 ; 1.811	1.065 ; 1.113	0.935 ; 0.954	0.894 ; 0.952		0.290 ; 0.320	0.310 ; 0.210	0.380 ; 0.380	1.120 ; 1.220

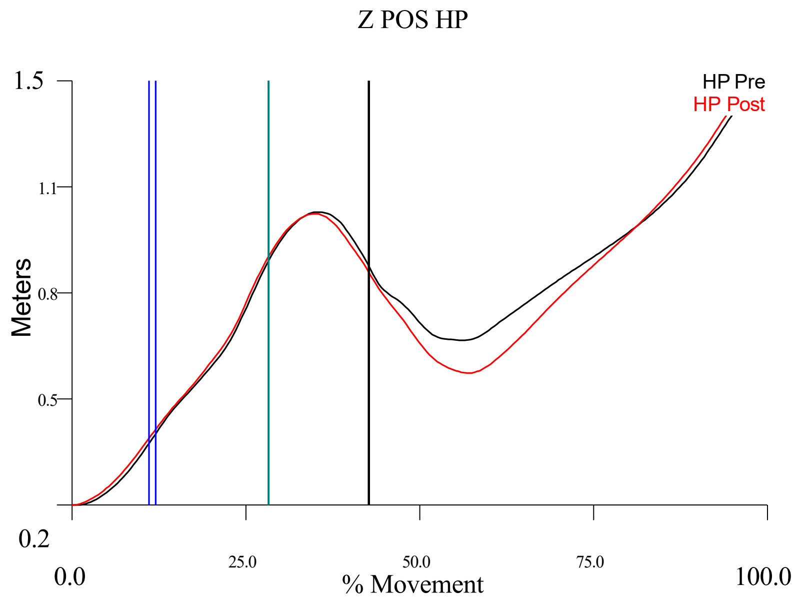
ANTERIOR POSTERIOR CHANGES

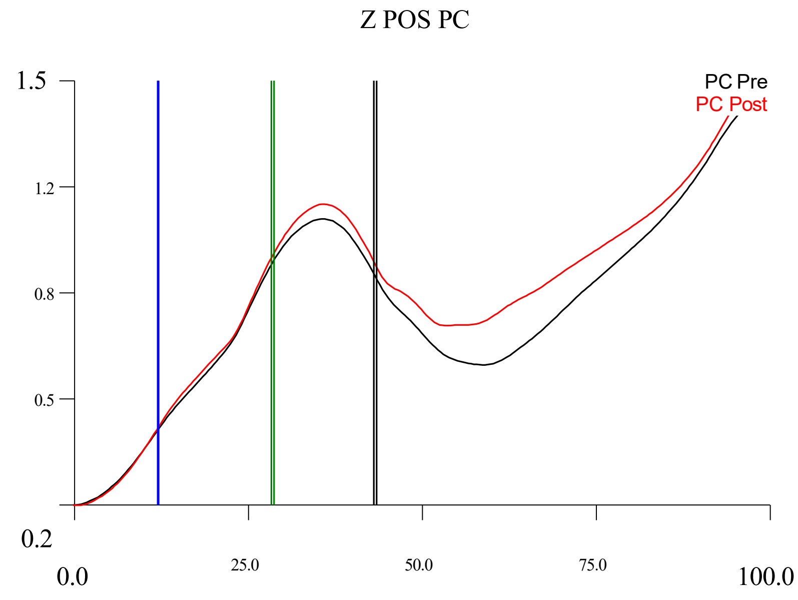
	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.076 ; -0.081	-0.071 ; -0.073
DxT: START TO CATCH	-0.064 ; -0.085	-0.057 ; -0.037
Dx2: START TO START OF 2ND PULL	-0.040 ; -0.053	-0.020 ; -0.045
DxV: 2ND PULL POSITION TO MOST FORWARD	0.052 ; 0.049	0.034 ; 0.082

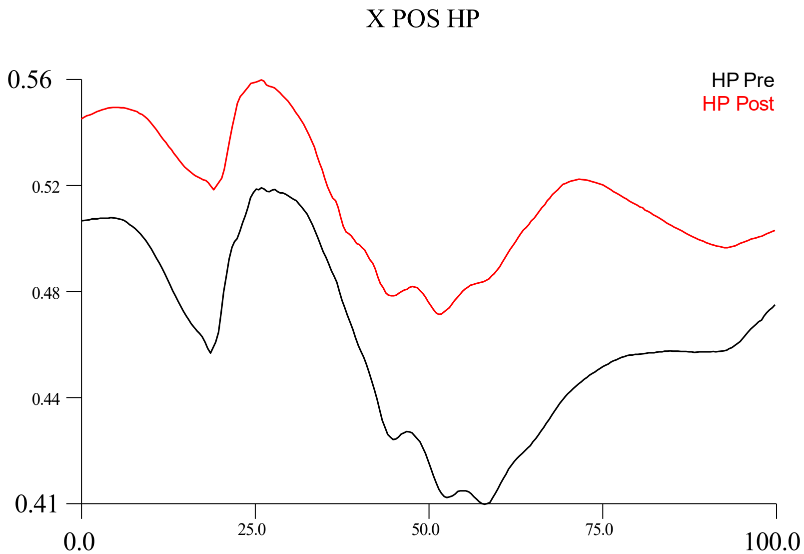


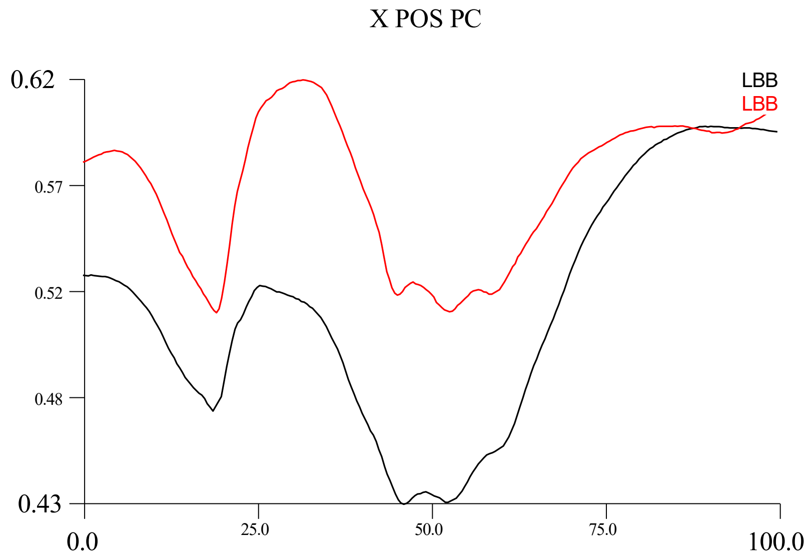


ATHLETE Report



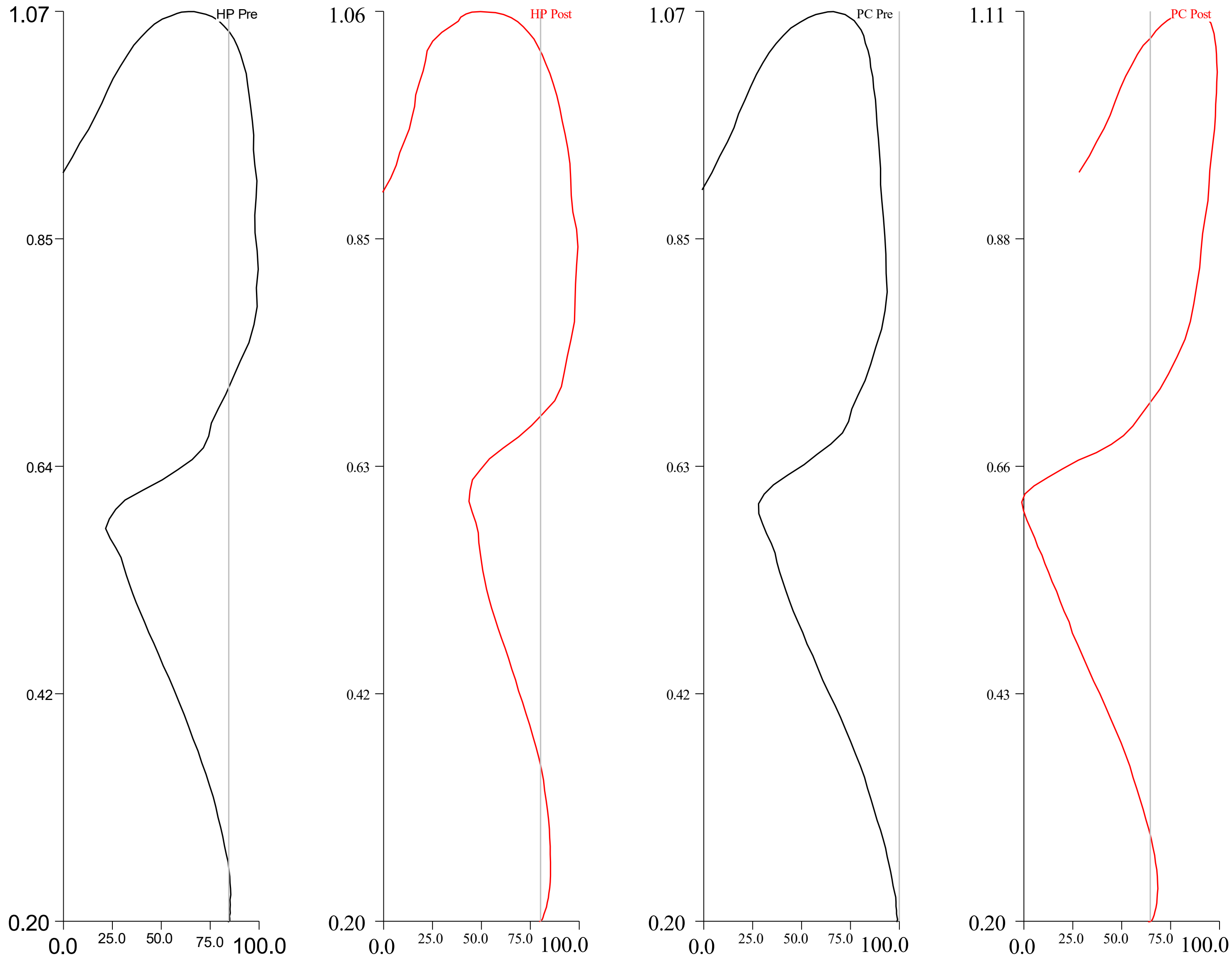






ANTERIOR POSTERIOR CHANGES HP VS PC

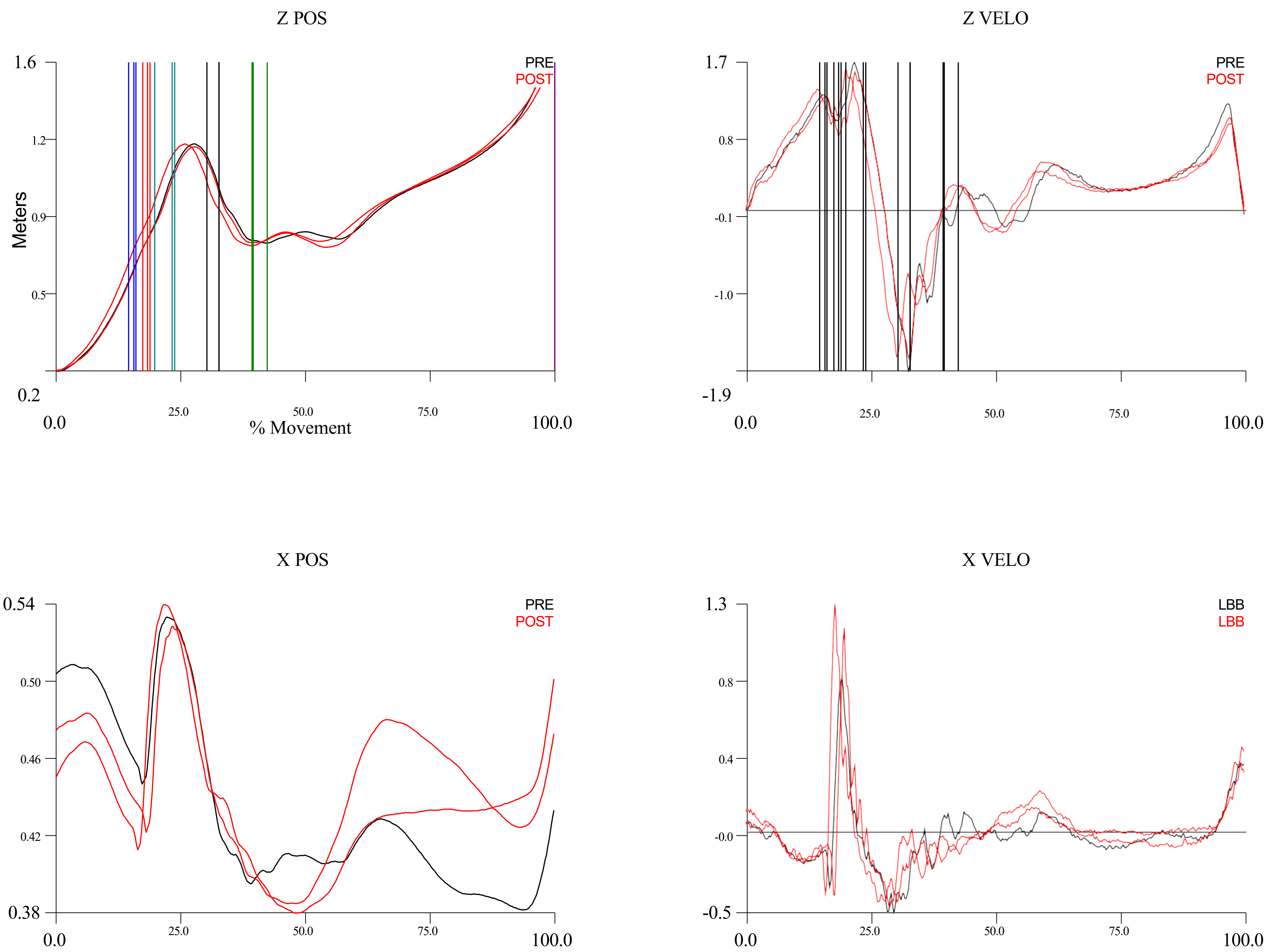
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.076	-0.071	-0.081	-0.073
DxT: START TO CATCH	-0.064	-0.057	-0.085	-0.037
Dx2: START TO START OF 2ND PULL	-0.040	-0.020	-0.053	-0.045
DxV: 2ND PULL POSITION TO MOST FORWARD	0.052	0.034	0.049	0.082

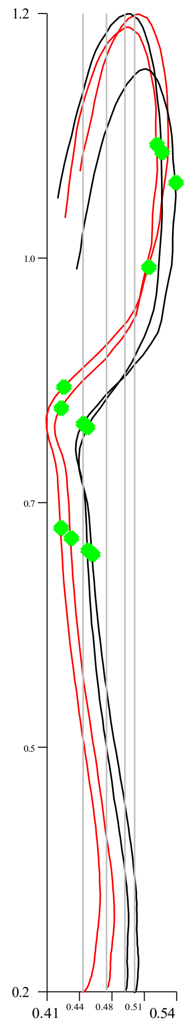


PRE VS POST METRICS

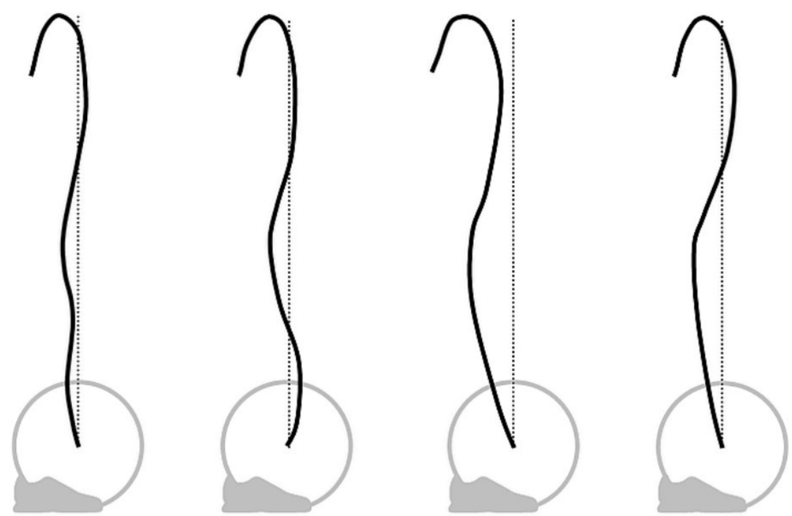
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.776	1.070	0.924	0.917		0.310	0.290	0.370	1.130
HP POST	1.783	1.065	0.935	0.894		0.290	0.310	0.380	1.120
PC PRE	1.786	1.069	0.919	0.899		0.300	0.280	0.380	1.020
PC POST	1.811	1.113	0.954	0.952		0.320	0.210	0.380	1.220

Potentiation Report





POST
PRE



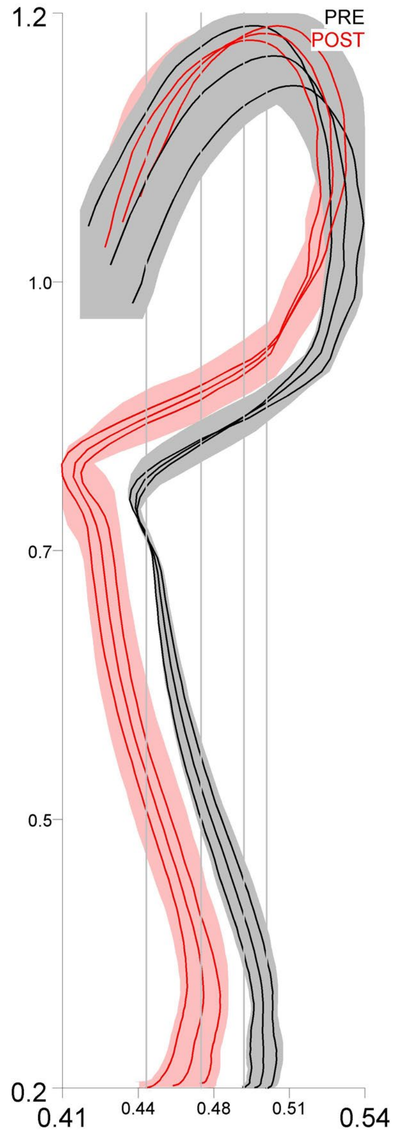
Type 4 Type 3 Type 2 Type 1

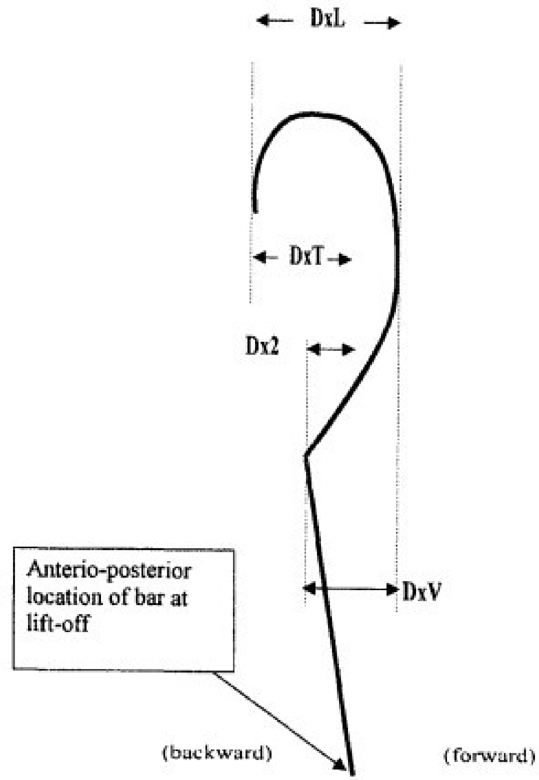
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.523 ; 1.728 ;;	1.154 ; 1.211 ;;	1.037 ; 1.068 ;;	0.948 ; 1.021 ;;	-1.928 ;;	0.650 ; 0.630 ;;	0.200 ; 0.200 ;;	0.380 ; 0.380 ;;	2.330 ;;
POST	1.616 ; 1.538 ;;	1.197 ; 1.211 ;;	1.076 ; 0.950 ;;	1.001 ; 1.049 ;;	-1.857 ; -1.911 ;;	0.680 ; 0.610 ;;	0.210 ; 0.100 ;;	0.380 ; 0.440 ;;	2.580 ; 2.540 ;;

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.102 ; -0.108 ;;	-0.095 ; -0.091 ;;
DxT: START TO CATCH	-0.049 ; -0.079 ;;	-0.042 ; -0.002 ;;
Dx2: START TO START OF 2ND PULL	-0.043 ; -0.049 ;;	-0.047 ; -0.020 ;;
DxV: 2ND PULL POSITION TO MOST FORWARD	0.096 ; 0.078 ;;	0.100 ; 0.109 ;;





LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

DxL = most forward position to catch

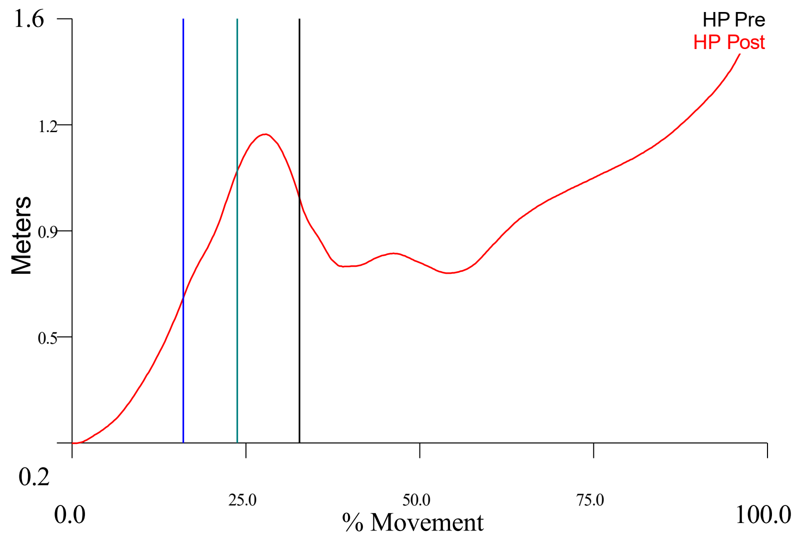
DxT = start position to catch position

Dx2 = start position to beginning of 2nd pull

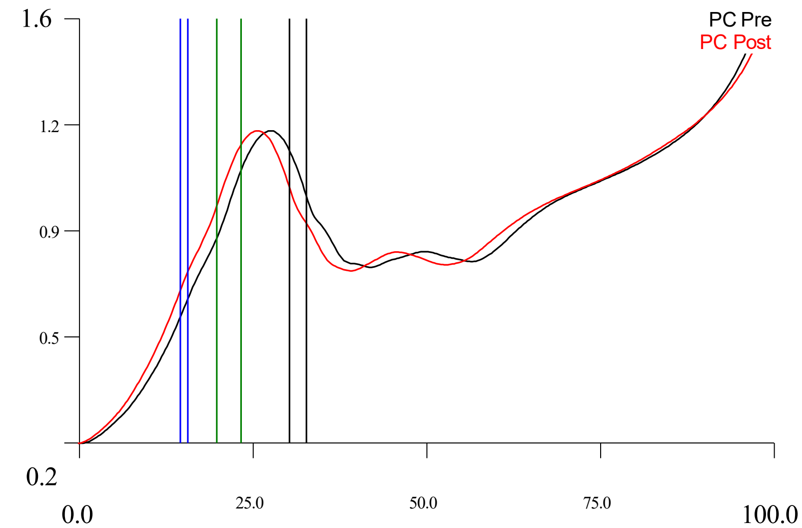
DxV = 2nd pull position to most forward position

ATHLETE Report

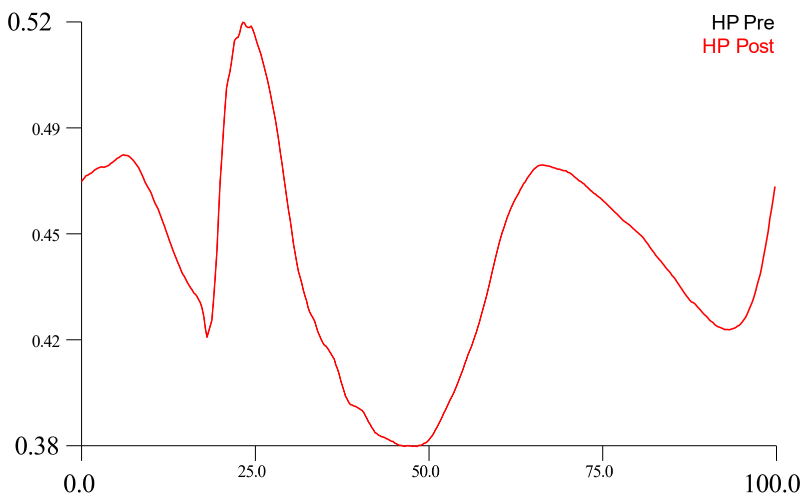
Z POS HP



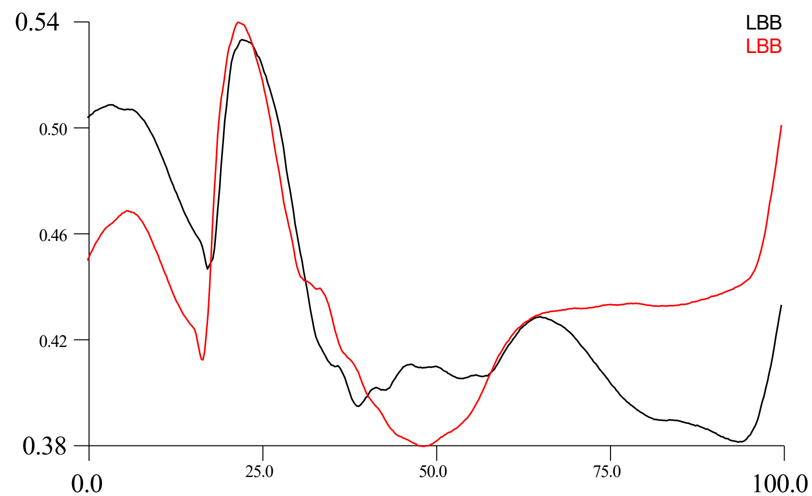
Z POS PC



X POS HP

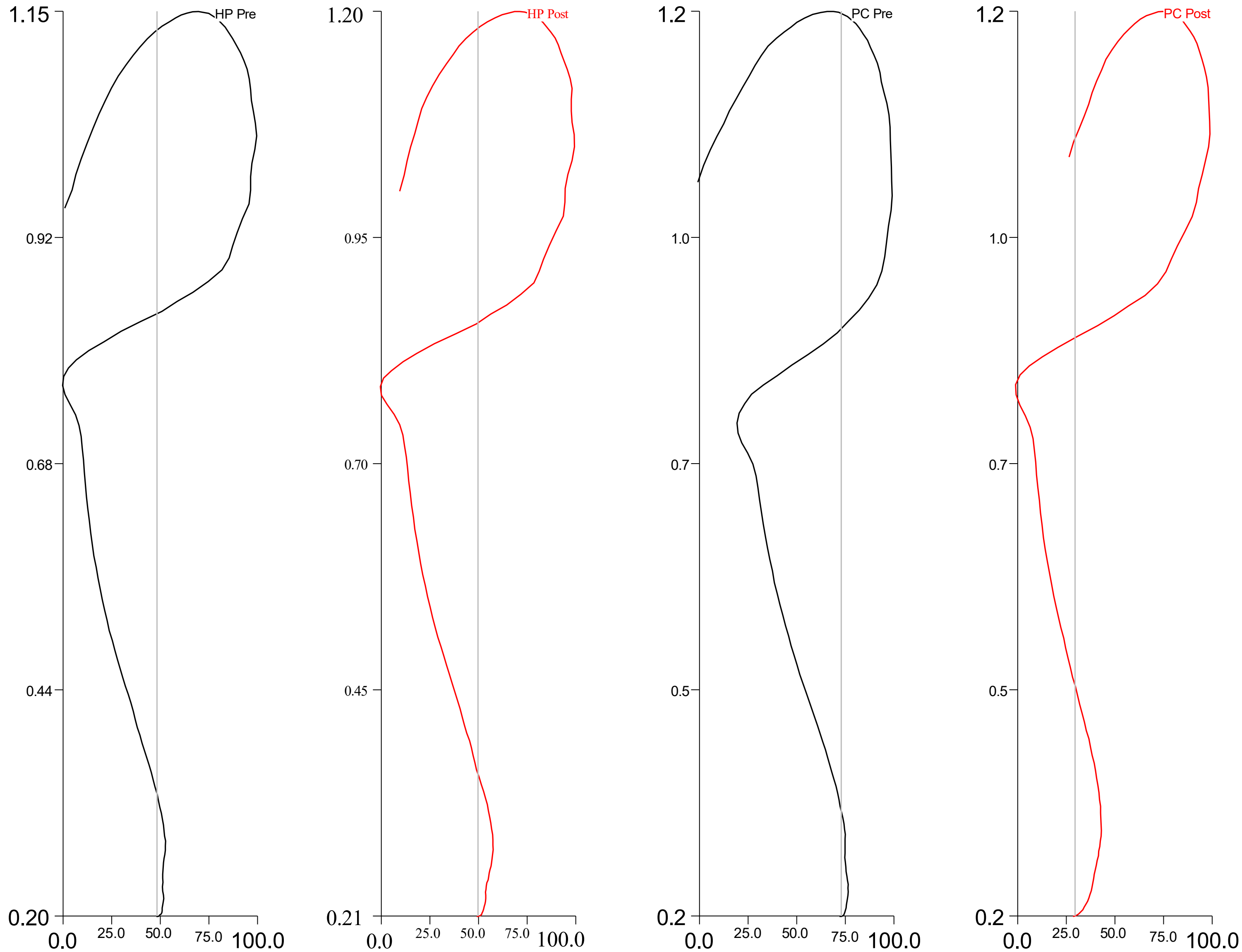


X POS PC



ANTERIOR POSTERIOR CHANGES HP VS PC

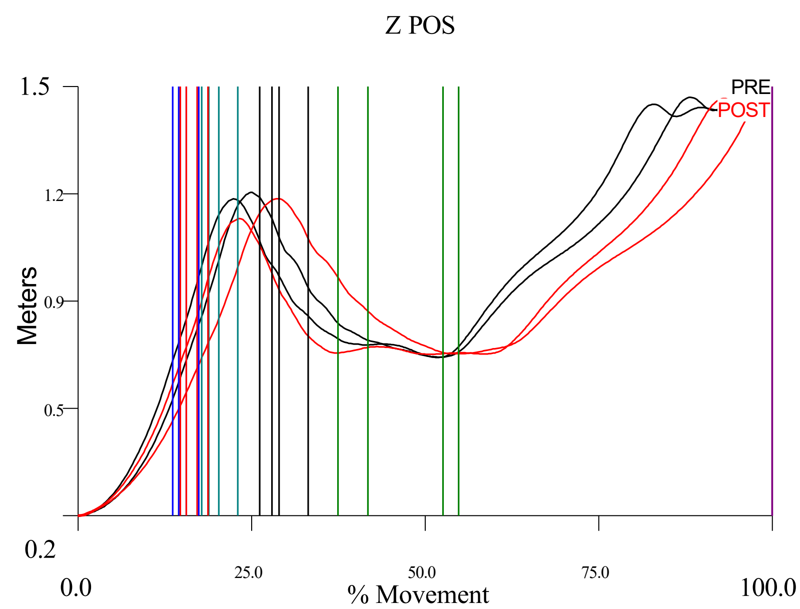
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.102 ;	-0.095 ;	-0.108 ;	-0.091 ;
DxT: START TO CATCH	-0.049 ;	-0.042 ;	-0.079 ;	-0.002 ;
Dx2: START TO START OF 2ND PULL	-0.043 ;	-0.047 ;	-0.049 ;	-0.020 ;
DxV: 2ND PULL POSITION TO MOST FORWARD	0.096 ;	0.100 ;	0.078 ;	0.109 ;

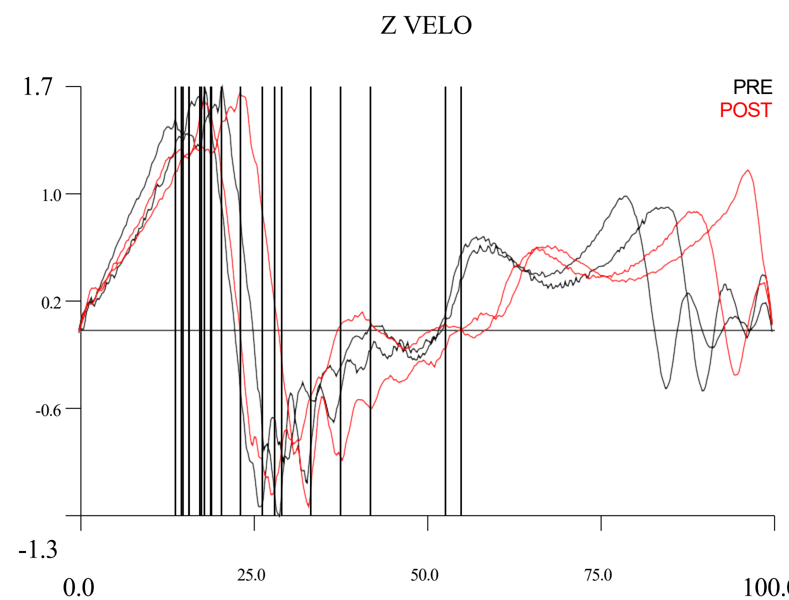


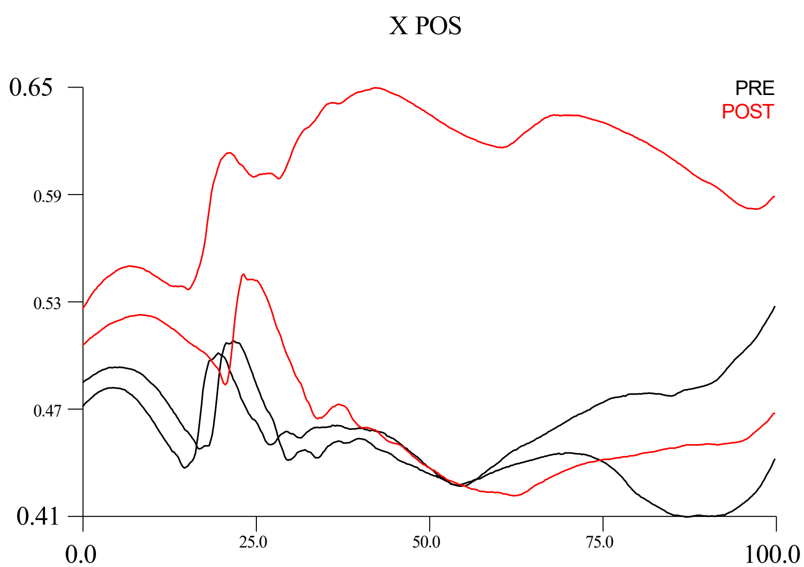
PRE VS POST METRICS

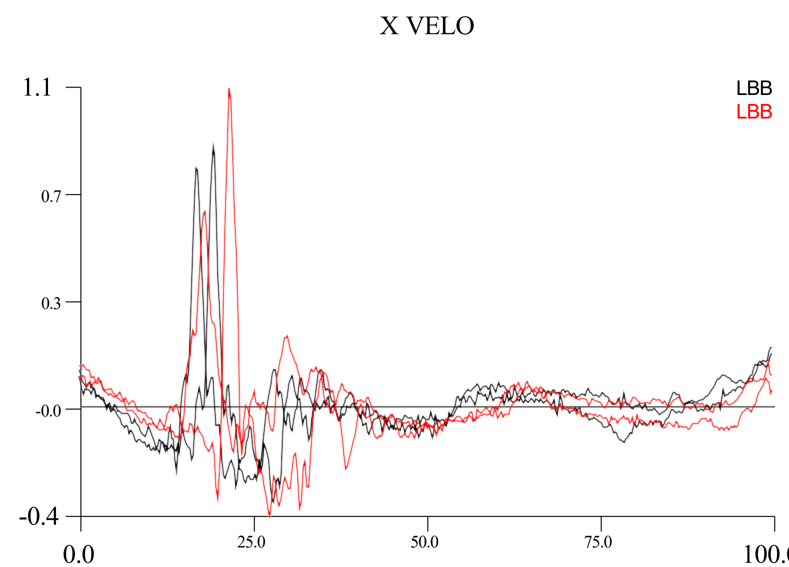
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.523 ;	1.154 ;	1.037 ;	0.948 ;		0.650 ;	0.200 ;	0.380 ;	
HP POST	1.616 ;	1.197 ;	1.076 ;	1.001 ;	-1.857 ;	0.680 ;	0.210 ;	0.380 ;	2.580 ;
PC PRE	1.728 ;	1.211 ;	1.068 ;	1.021 ;	-1.928 ;	0.630 ;	0.200 ;	0.380 ;	2.330 ;
PC POST	1.538 ;	1.211 ;	0.950 ;	1.049 ;	-1.911 ;	0.610 ;	0.100 ;	0.440 ;	2.540 ;

Potentiation Report

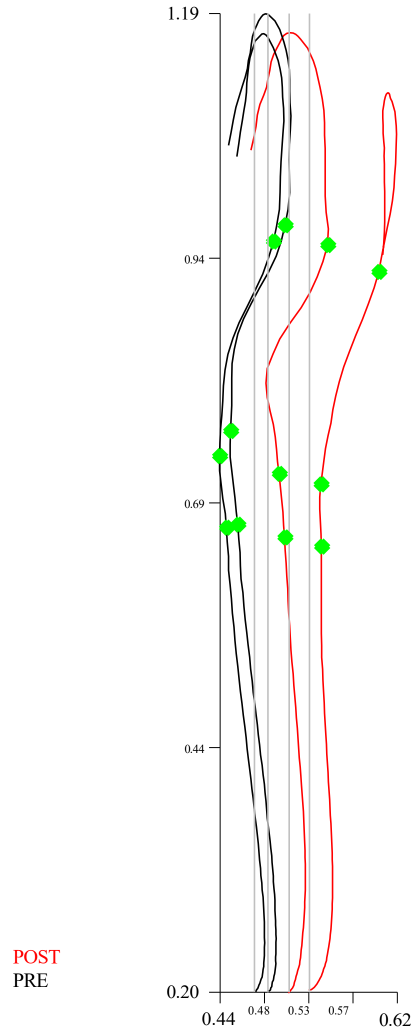


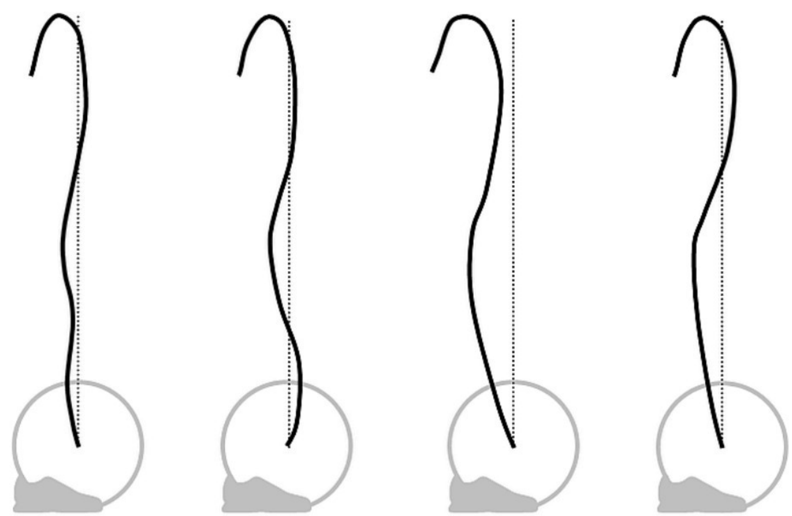






Barbell Trajectory





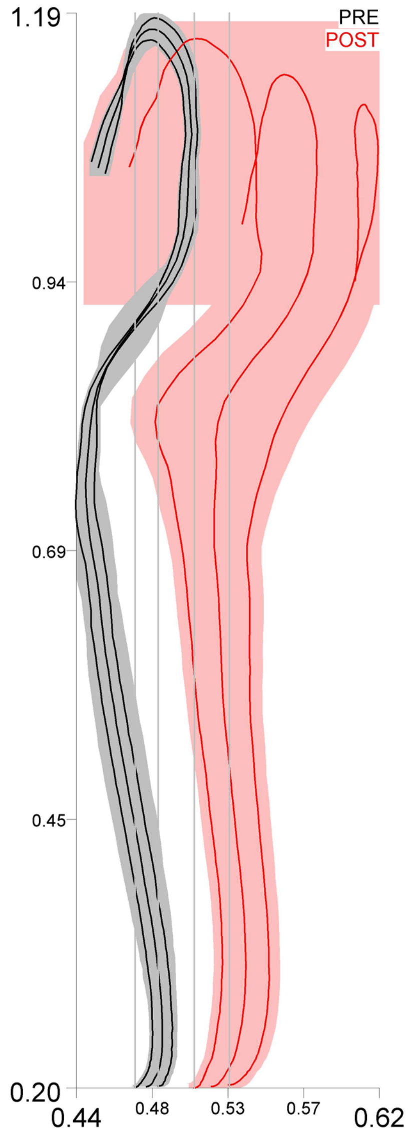
Type 4 Type 3 Type 2 Type 1

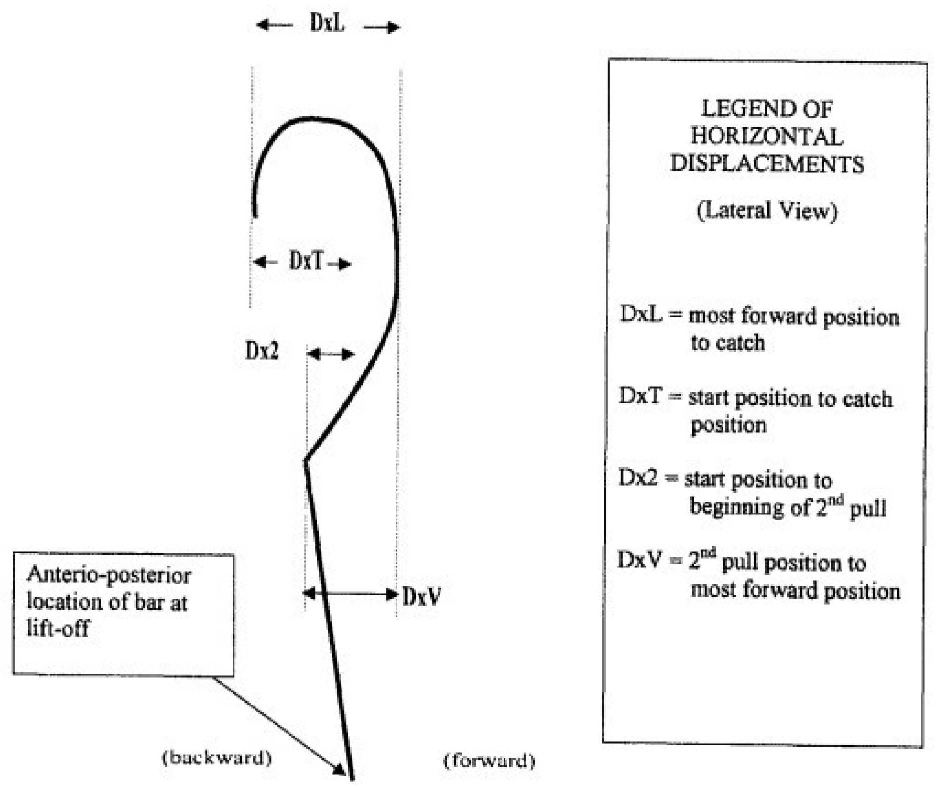
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.654 ; 1.597	1.165 ; 1.185	0.955 ; 0.972	1.042 ; 1.053	-1.663 ; -1.747	0.620 ; 0.700	0.140 ; 0.140	0.380 ; 0.390	2.650 ; 2.130
POST	1.613 ; 1.647	1.106 ; 1.166	0.925 ; 0.952	0.942 ; 1.048	-1.809 ; -1.732	0.670 ; 0.650	0.150 ; 0.160	0.420 ; 0.380	2.890 ; 1.690

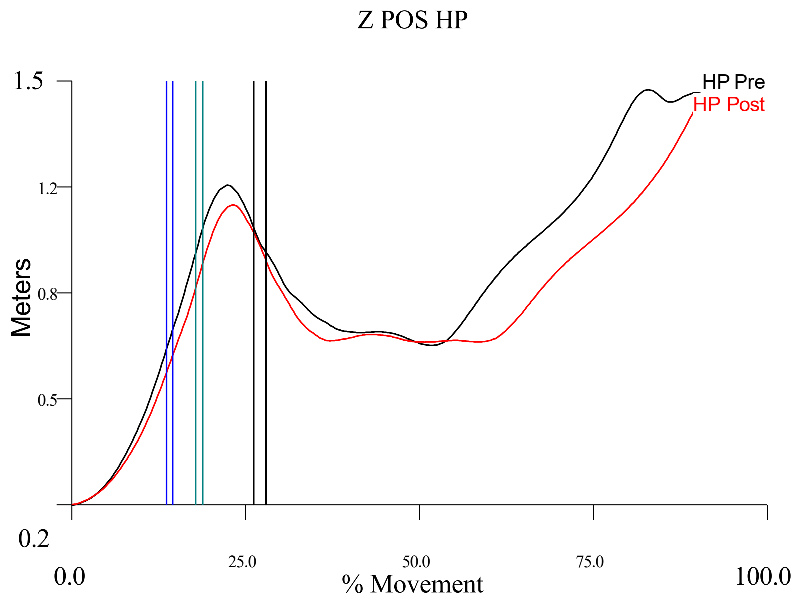
ANTERIOR POSTERIOR CHANGES

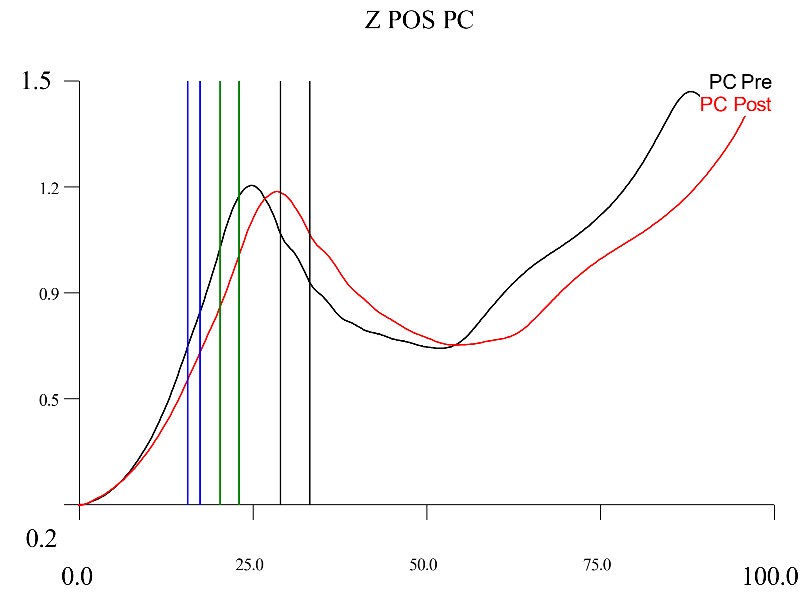
	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.047 ; -0.063	-0.014 ; -0.078
DxT: START TO CATCH	-0.017 ; -0.039	0.075 ; -0.038
Dx2: START TO START OF 2ND PULL	-0.035 ; -0.037	0.012 ; -0.009
DxV: 2ND PULL POSITION TO MOST FORWARD	0.065 ; 0.061	0.076 ; 0.050

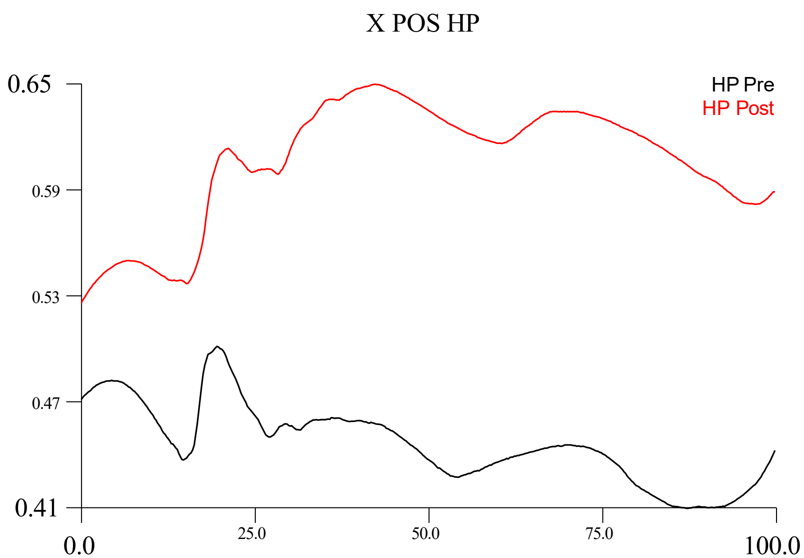


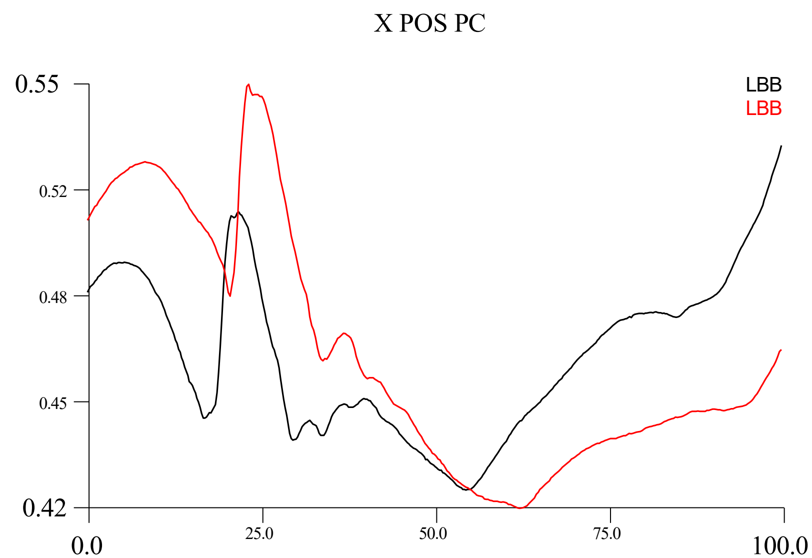


ATHLETE Report



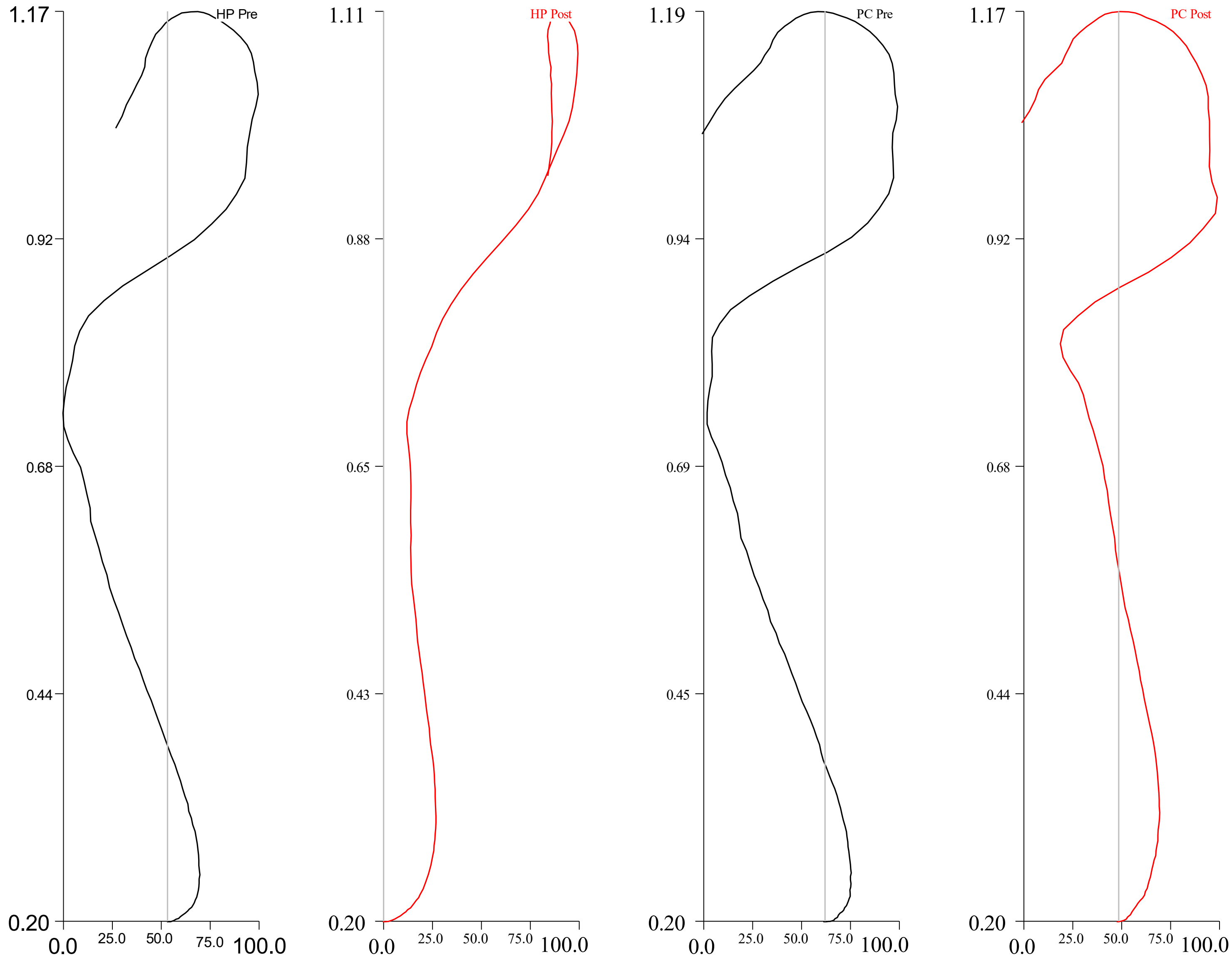






ANTERIOR POSTERIOR CHANGES HP VS PC

	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.047	-0.014	-0.063	-0.078
DxT: START TO CATCH	-0.017	0.075	-0.039	-0.038
Dx2: START TO START OF 2ND PULL	-0.035	0.012	-0.037	-0.009
DxV: 2ND PULL POSITION TO MOST FORWARD	0.065	0.076	0.061	0.050

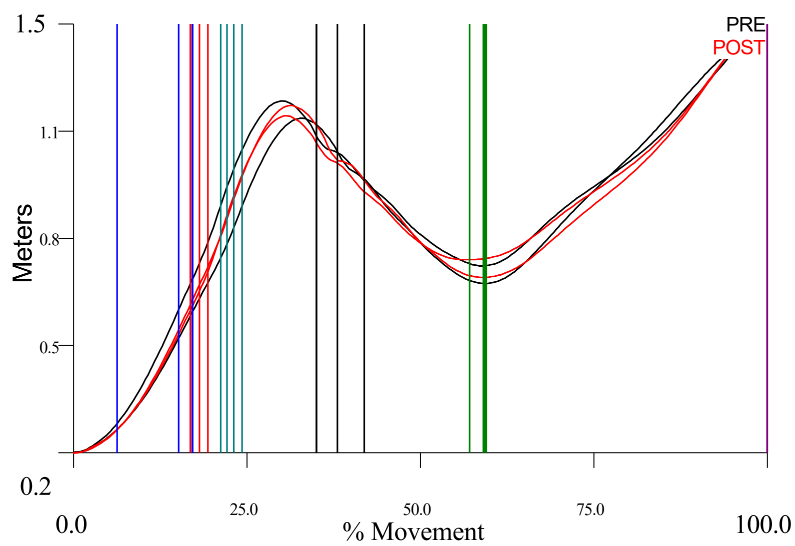


PRE VS POST METRICS

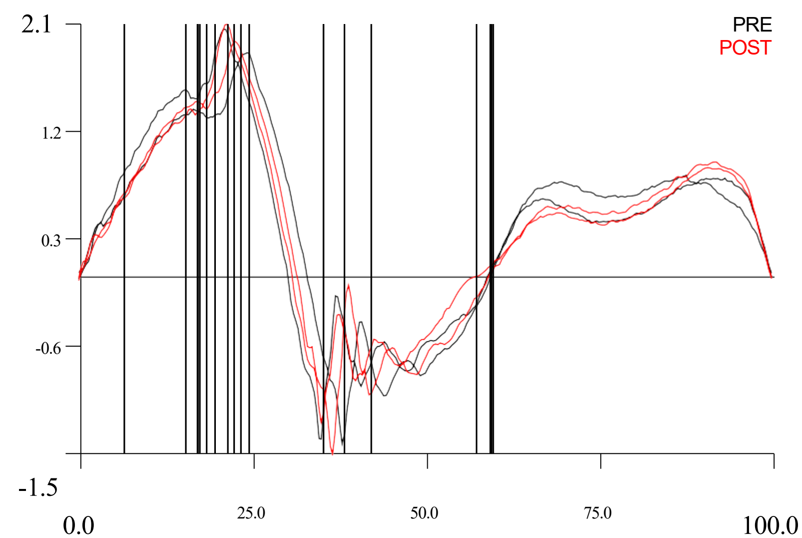
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.654	1.165	0.955	1.042	-1.663	0.620	0.140	0.380	2.650
HP POST	1.613	1.106	0.925	0.942	-1.809	0.670	0.150	0.420	2.890
PC PRE	1.597	1.185	0.972	1.053	-1.747	0.700	0.140	0.390	2.130
PC POST	1.647	1.166	0.952	1.048	-1.732	0.650	0.160	0.380	1.690

Potentiation Report

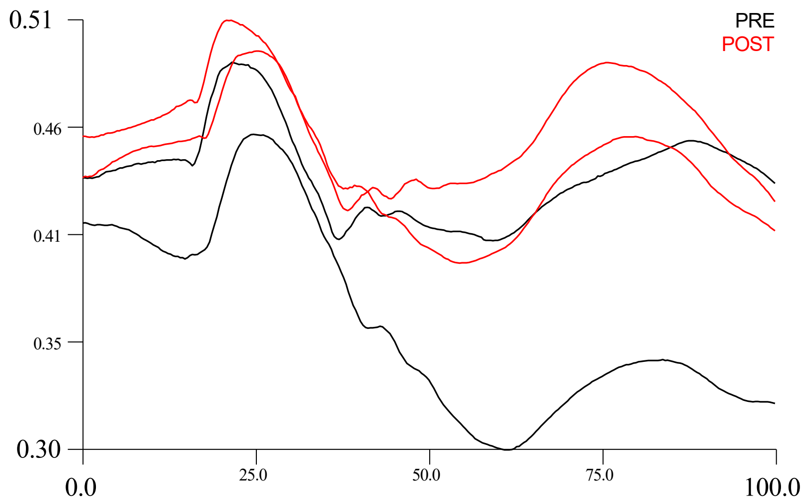
Z POS



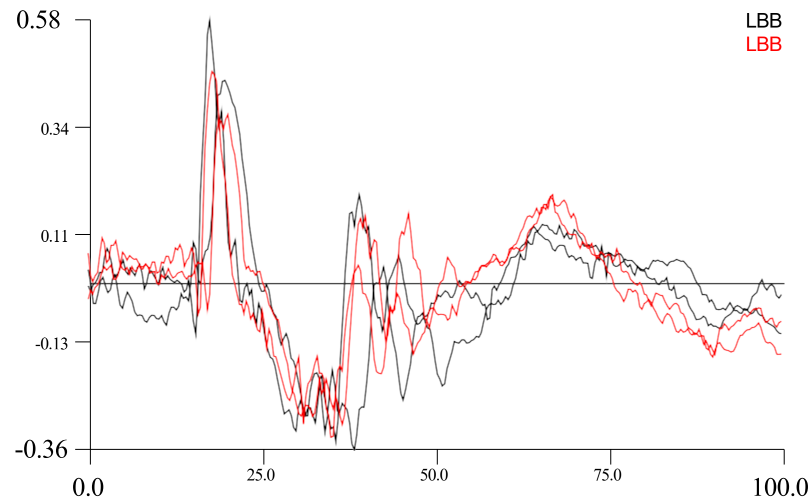
Z VELO



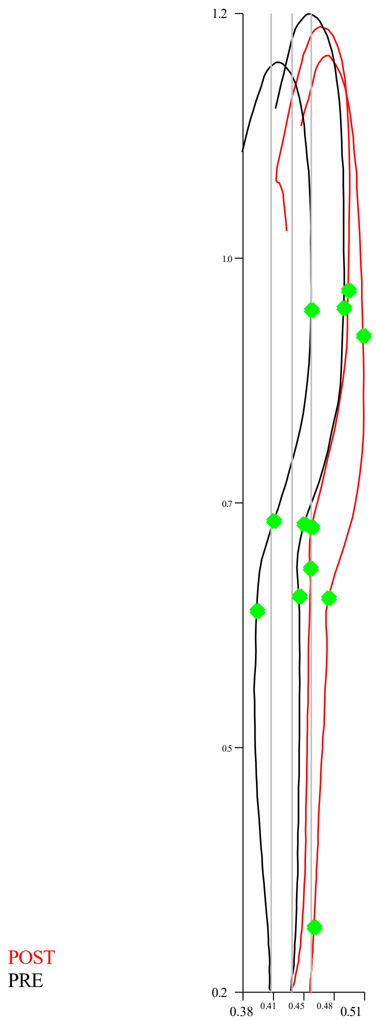
X POS

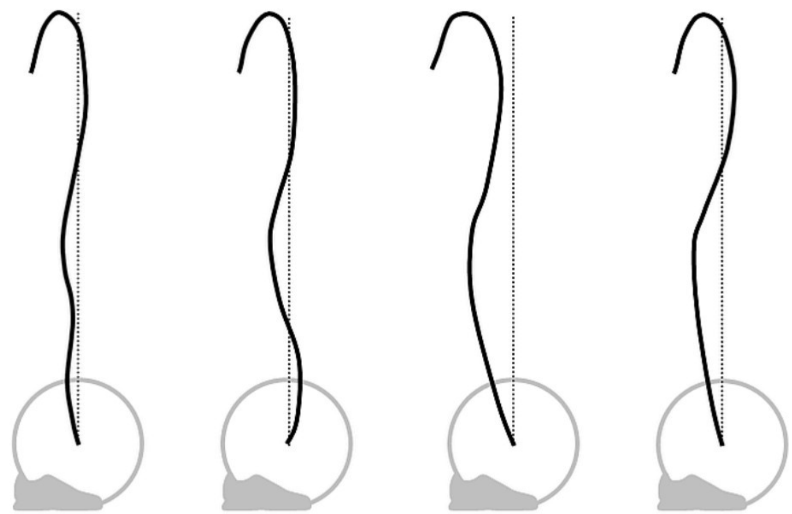


X VELO



Barbell Trajectory





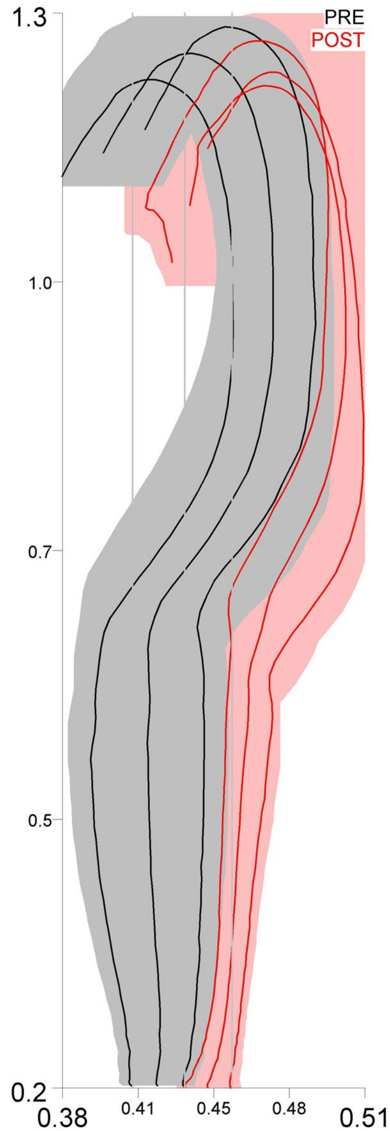
Type 4 Type 3 Type 2 Type 1

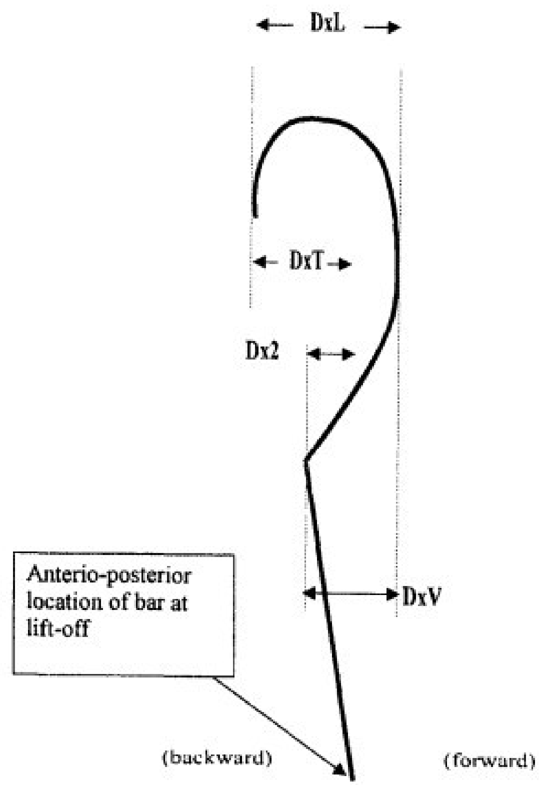
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	2.085 ; 1.889	1.241 ; 1.189	0.927 ; 0.925	1.140 ; 1.094	-1.809 ; -1.920	0.450 ; 0.480	0.130 ; 0.140	0.410 ; 0.390	1.210 ; 1.150
POST	2.128 ; 1.986	1.196 ; 1.227	0.897 ; 0.946	1.121 ; 1.009	-1.671 ; -1.144	0.190 ; 0.520	0.160 ; 0.150	0.390 ; 0.160	1.300 ; 1.240

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.073 ; -0.073	-0.067 ; -0.067
DxT: START TO CATCH	-0.017 ; -0.030	-0.010 ; -0.005
Dx2: START TO START OF 2ND PULL	0.013 ; 0.003	0.019 ; 0.021
DxV: 2ND PULL POSITION TO MOST FORWARD	0.043 ; 0.040	0.038 ; 0.041





LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

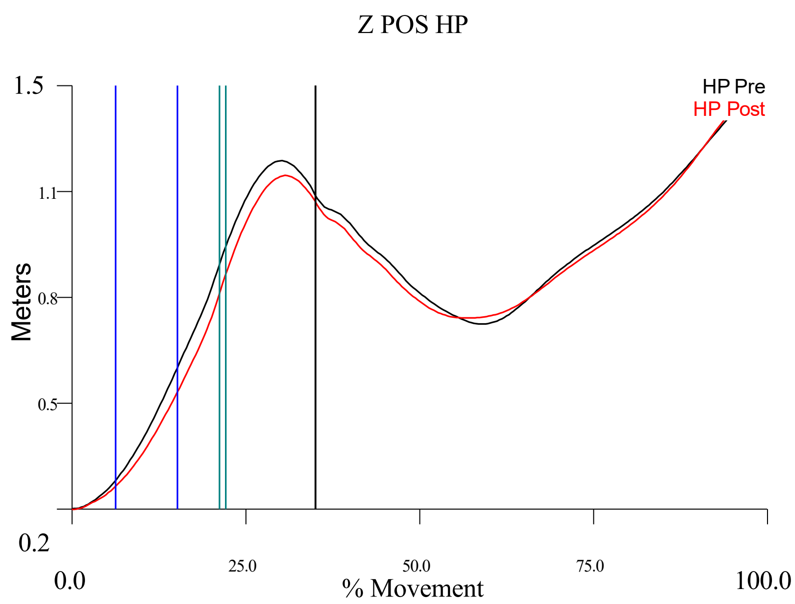
DxL = most forward position to catch

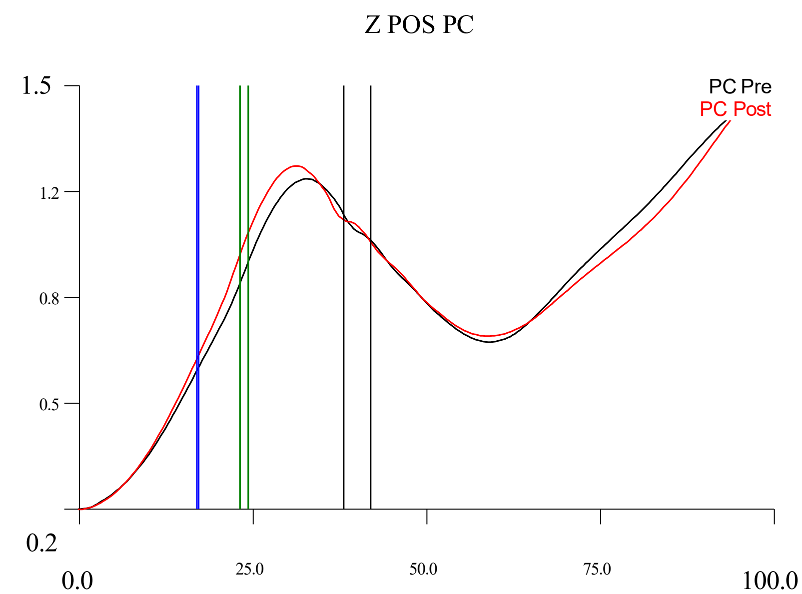
DxT = start position to catch position

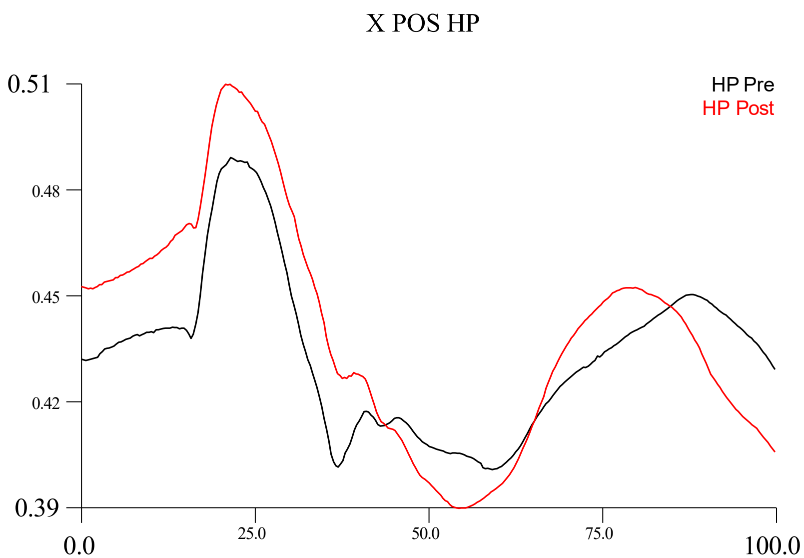
Dx2 = start position to beginning of 2nd pull

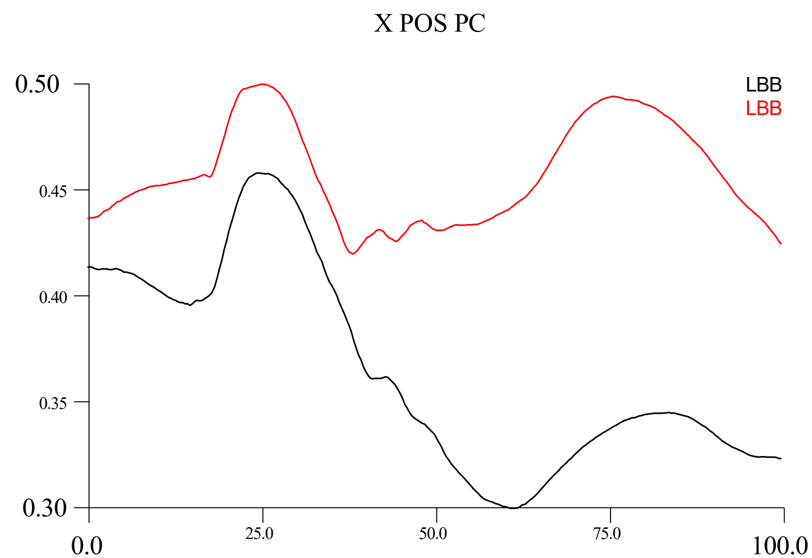
DxV = 2nd pull position to most forward position

ATHLETE Report



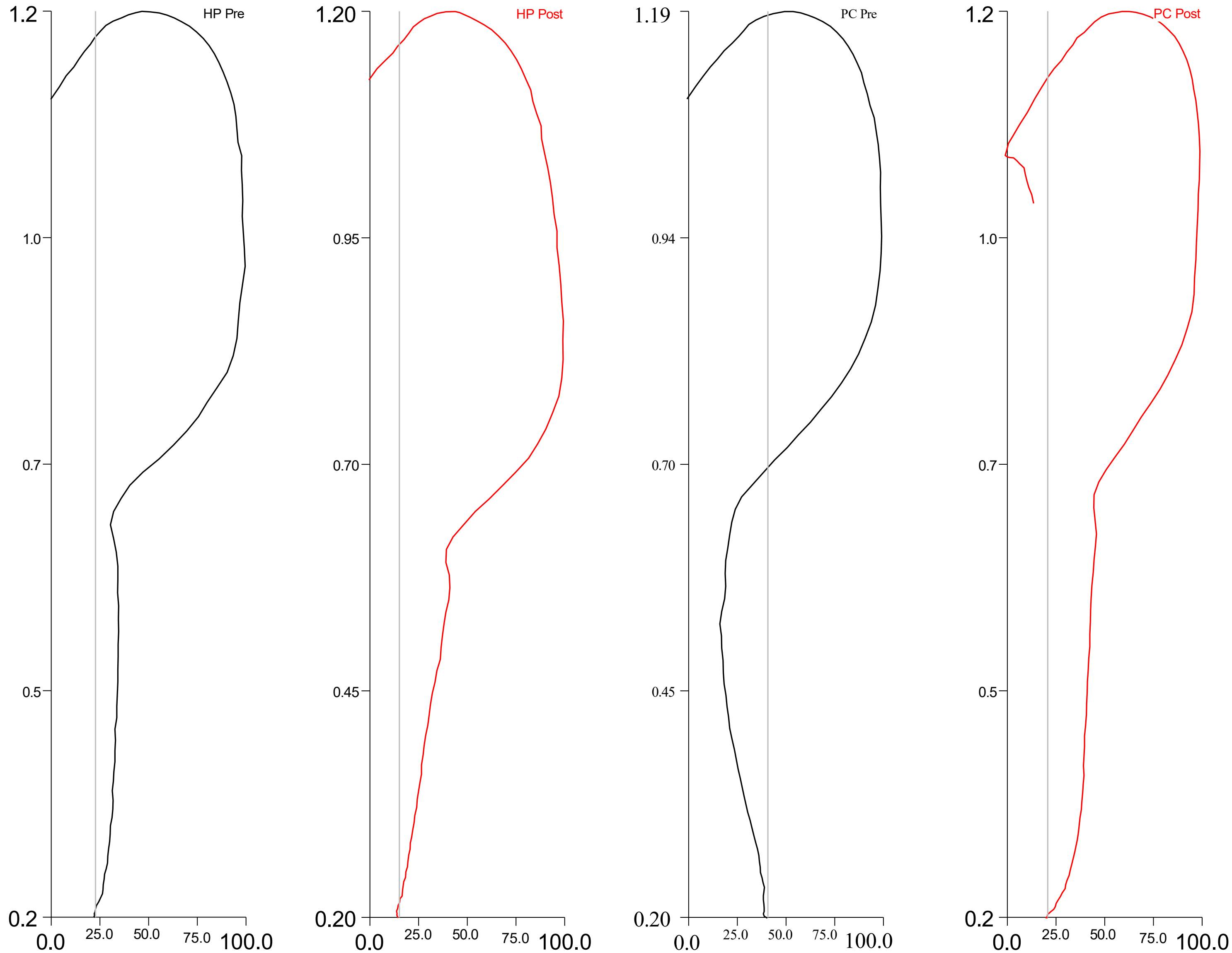






ANTERIOR POSTERIOR CHANGES HP VS PC

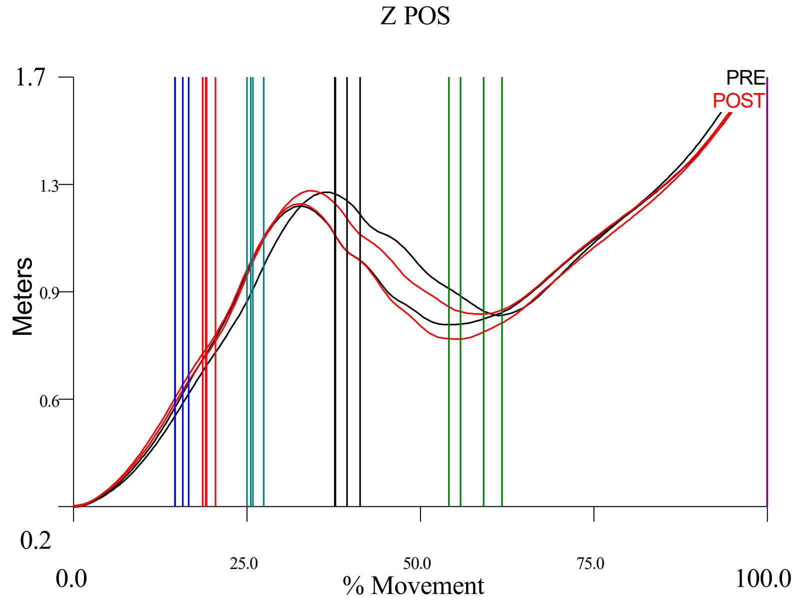
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.073	-0.067	-0.073	-0.067
DxT: START TO CATCH	-0.017	-0.010	-0.030	-0.005
Dx2: START TO START OF 2ND PULL	0.013	0.019	0.003	0.021
DxV: 2ND PULL POSITION TO MOST FORWARD	0.043	0.038	0.040	0.041

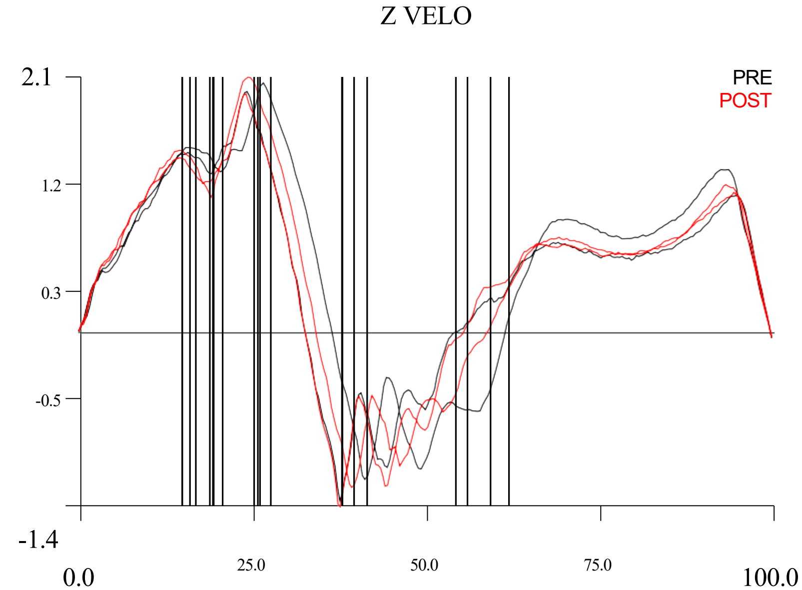


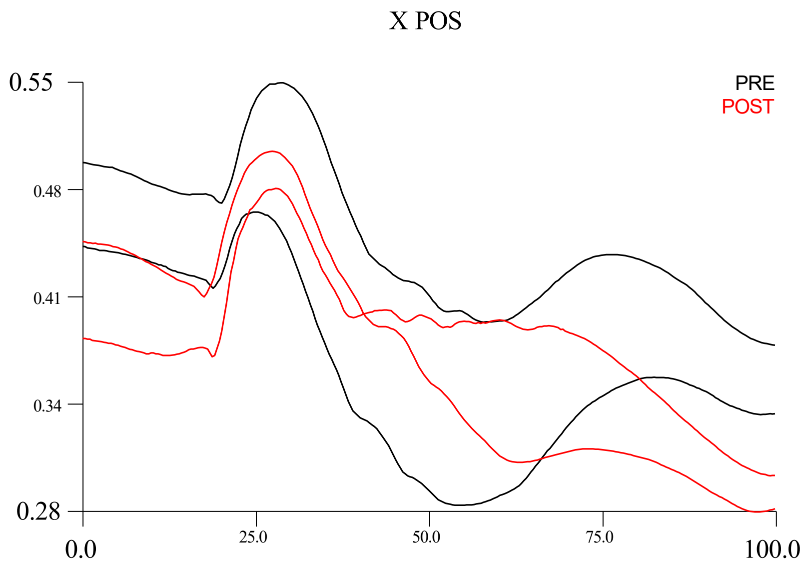
PRE VS POST METRICS

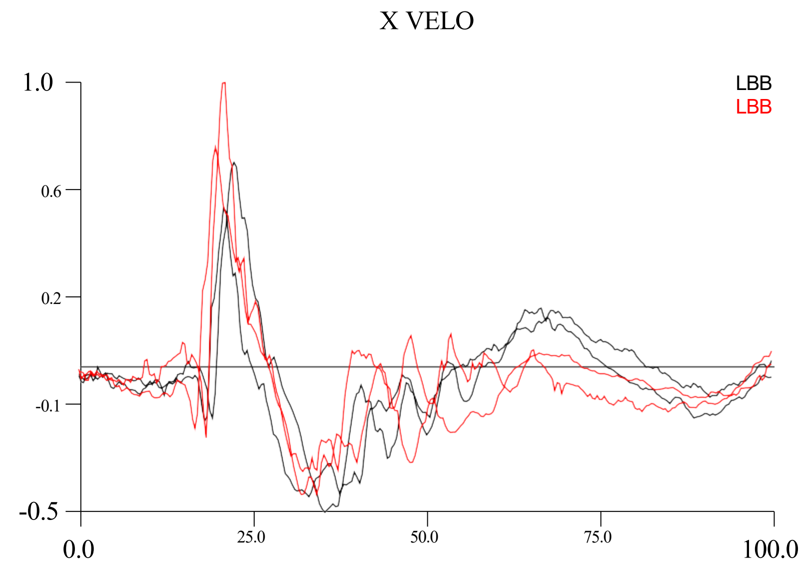
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	2.085	1.241	0.927	1.140	-1.809	0.450	0.130	0.410	1.210
HP POST	2.128	1.196	0.897	1.121	-1.671	0.190	0.160	0.390	1.300
PC PRE	1.889	1.189	0.925	1.094	-1.920	0.480	0.140	0.390	1.150
PC POST	1.986	1.227	0.946	1.009	-1.144	0.520	0.150	0.160	1.240

Potentiation Report

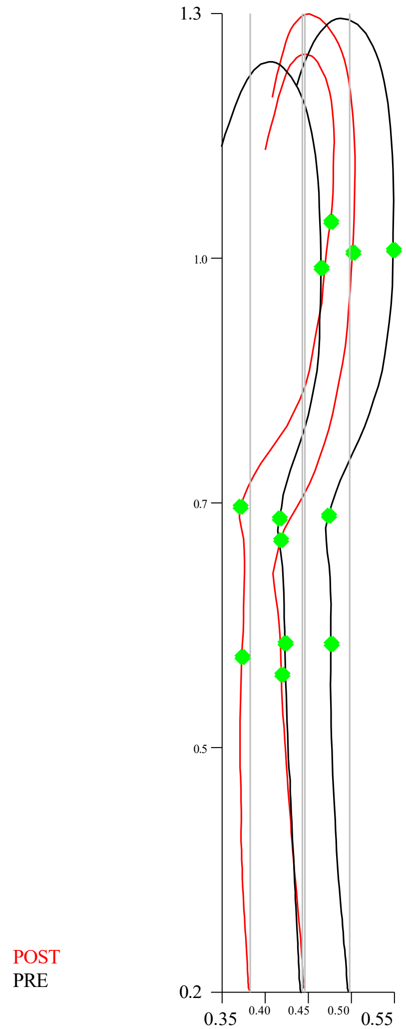


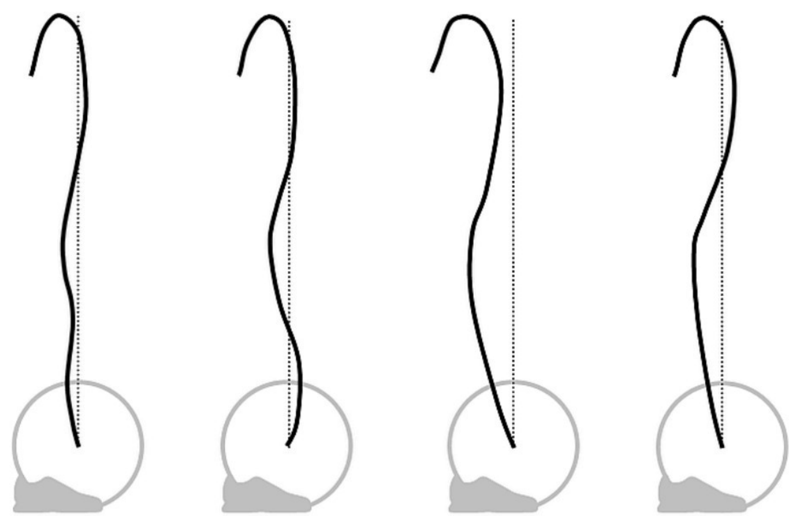






Barbell Trajectory





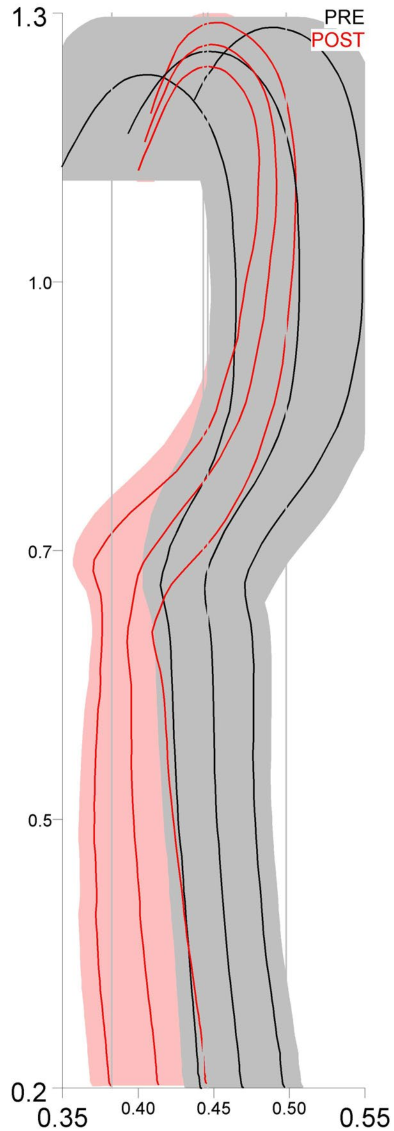
Type 4 Type 3 Type 2 Type 1

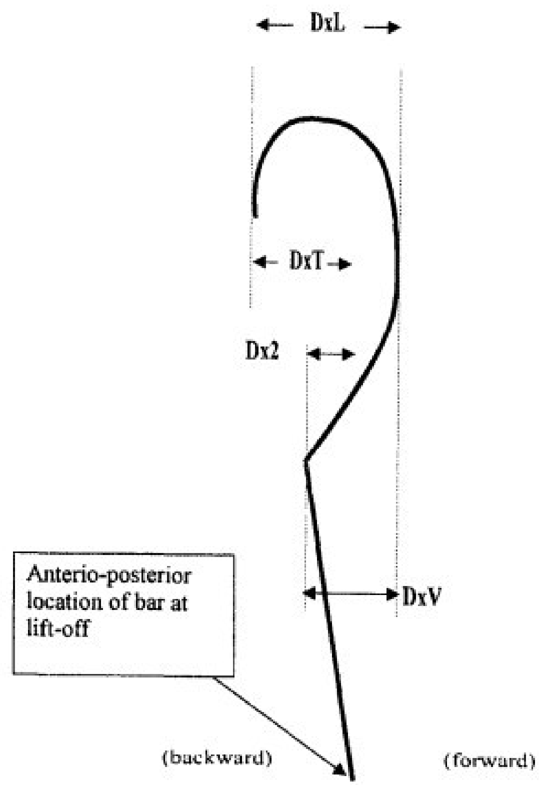
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.954 ; 2.025	1.230 ; 1.278	1.000 ; 1.020	1.136 ; 1.204	-2.075 ; -1.775	0.460 ; 0.430	0.170 ; 0.180	0.370 ; 0.360	1.340 ; 0.990
POST	1.933 ; 2.071	1.238 ; 1.283	1.052 ; 1.017	1.132 ; 1.190	-2.062 ; -1.681	0.430 ; 0.400	0.200 ; 0.190	0.350 ; 0.380	1.300 ; 1.120

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.110 ; -0.107	-0.077 ; -0.092
DxT: START TO CATCH	-0.089 ; -0.058	0.017 ; -0.035
Dx2: START TO START OF 2ND PULL	-0.025 ; -0.023	-0.011 ; -0.026
DxV: 2ND PULL POSITION TO MOST FORWARD	0.046 ; 0.073	0.105 ; 0.083





LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

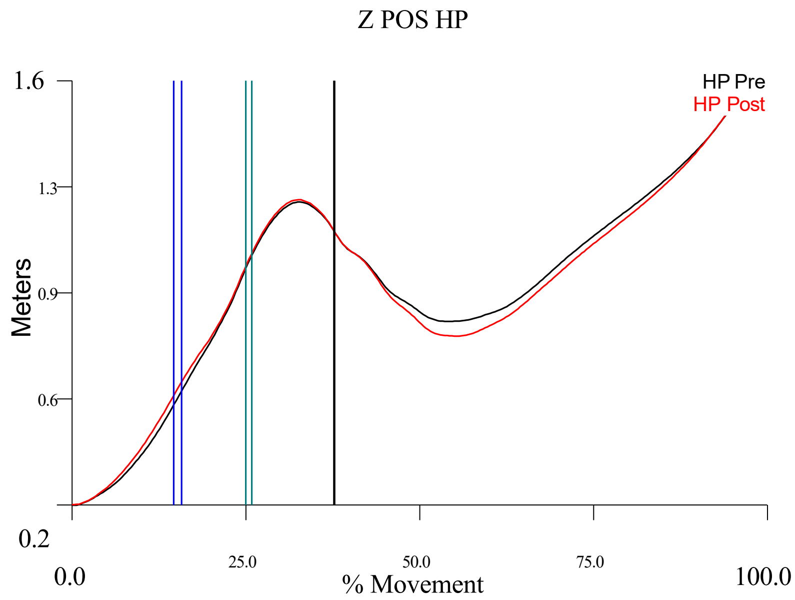
DxL = most forward position to catch

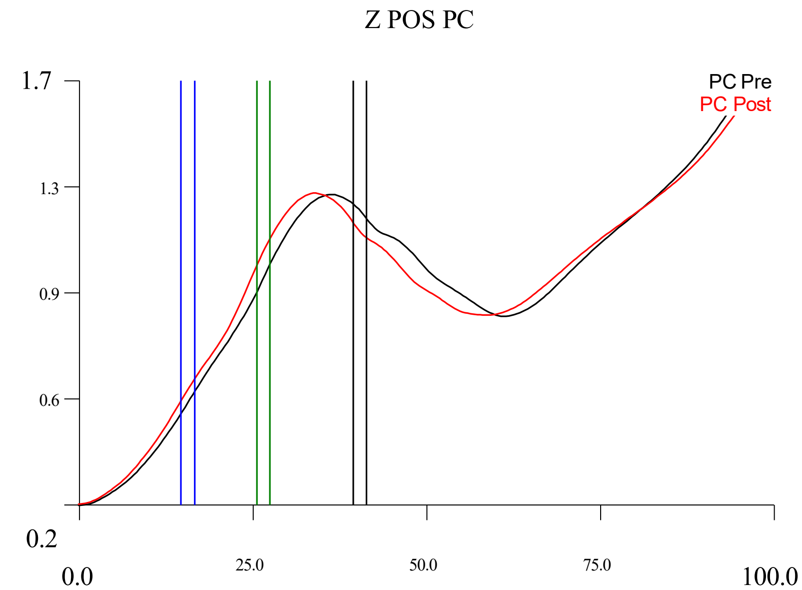
DxT = start position to catch position

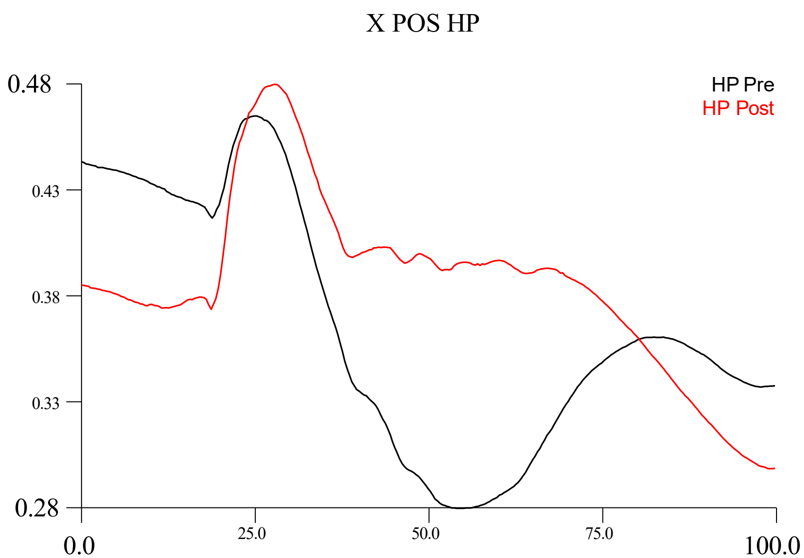
Dx2 = start position to beginning of 2nd pull

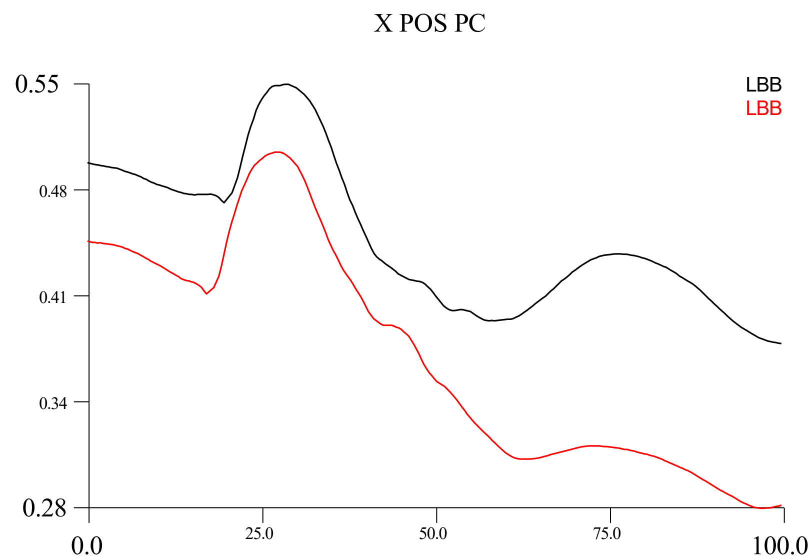
DxV = 2nd pull position to most forward position

ATHLETE Report



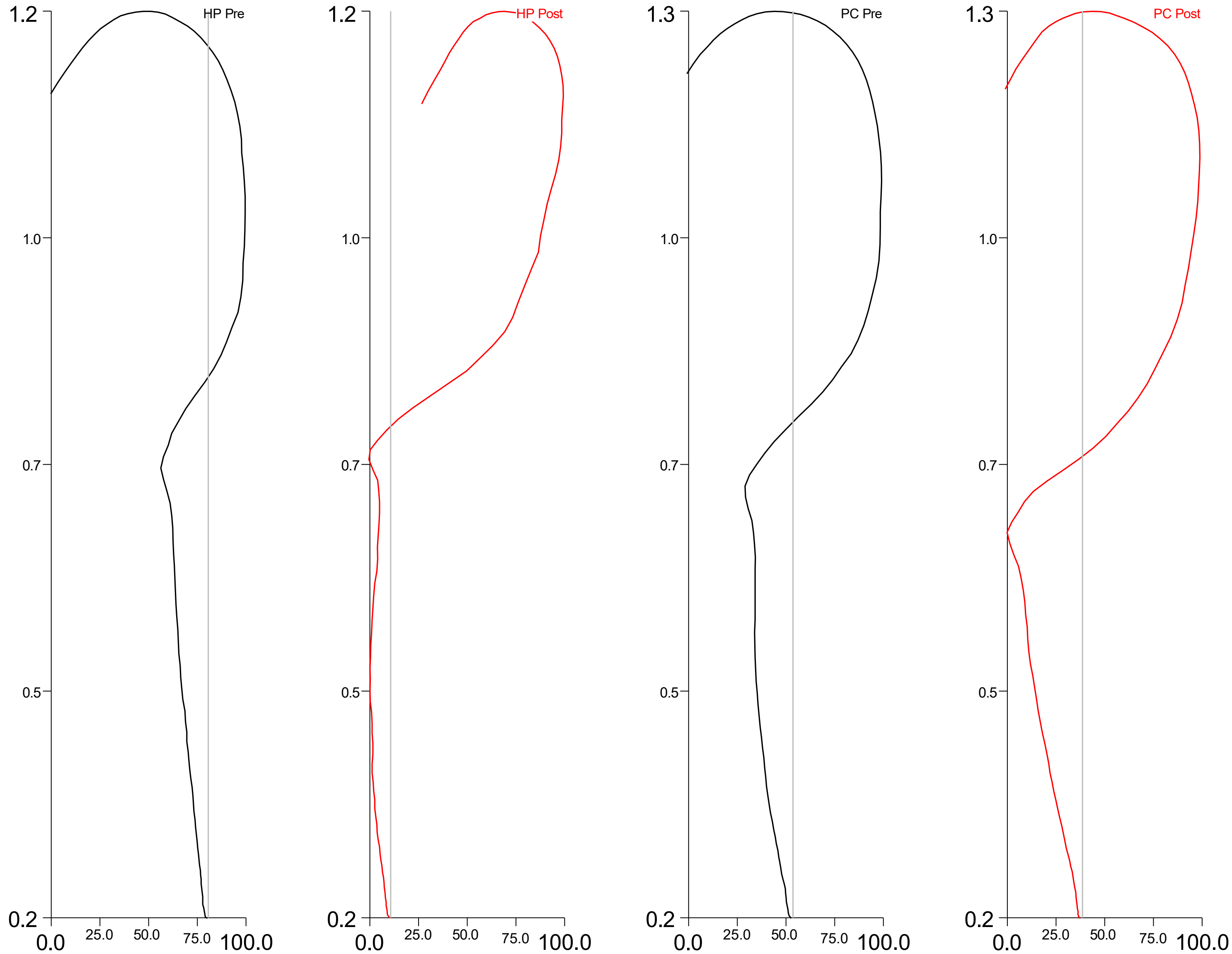






ANTERIOR POSTERIOR CHANGES HP VS PC

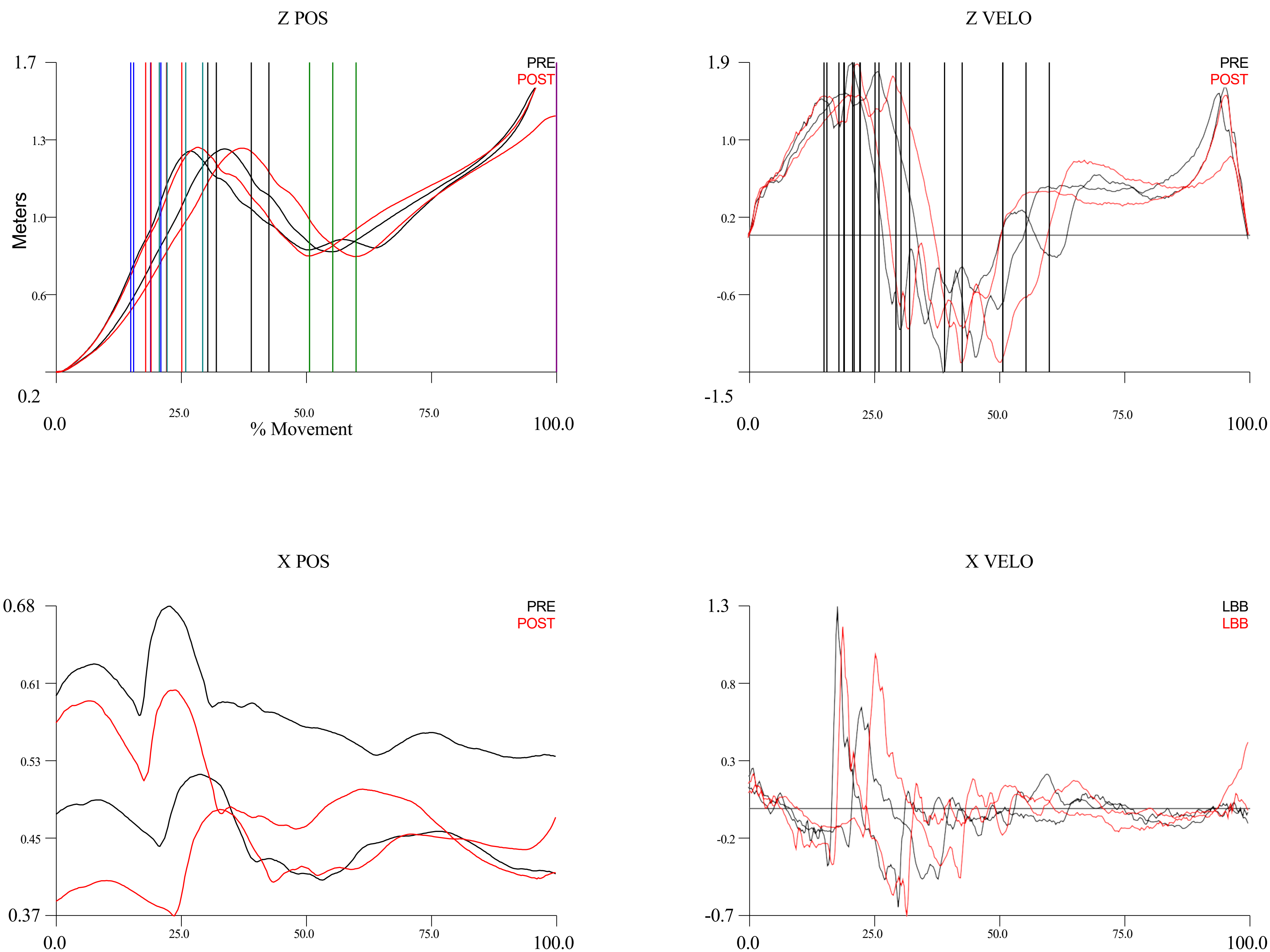
	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.110	-0.077	-0.107	-0.092
DxT: START TO CATCH	-0.089	0.017	-0.058	-0.035
Dx2: START TO START OF 2ND PULL	-0.025	-0.011	-0.023	-0.026
DxV: 2ND PULL POSITION TO MOST FORWARD	0.046	0.105	0.073	0.083



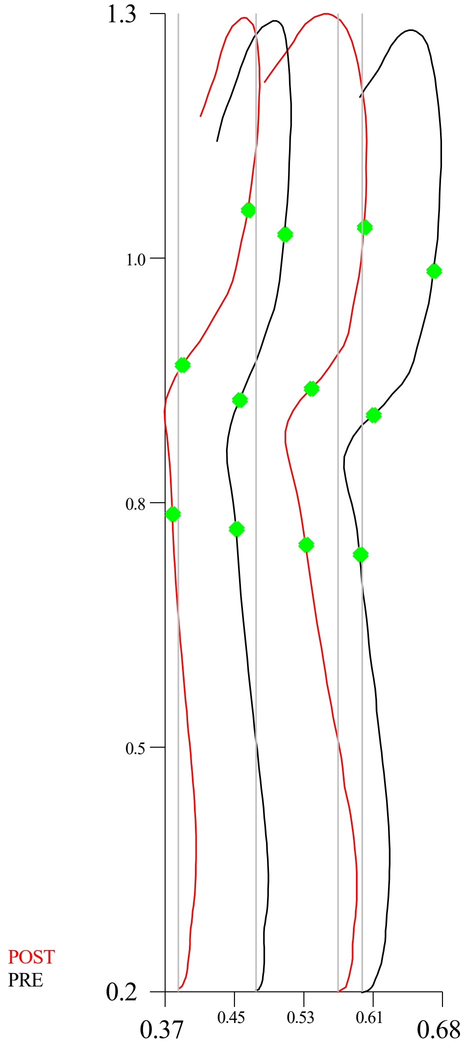
PRE VS POST METRICS

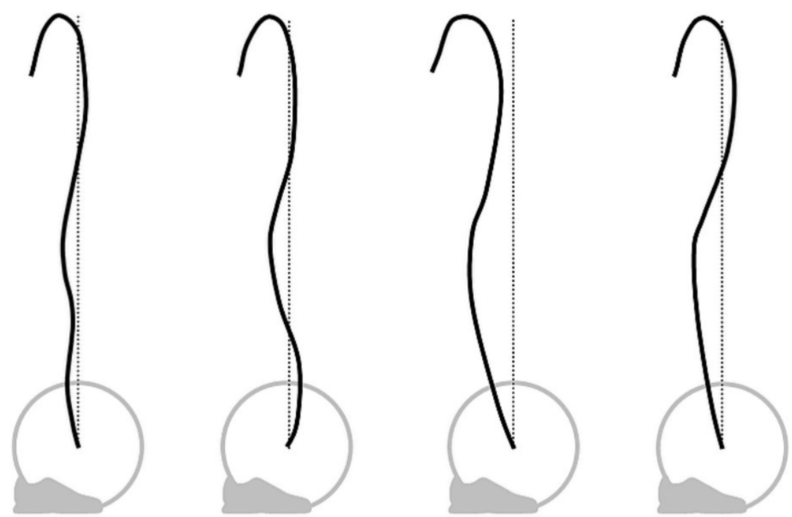
	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.954	1.230	1.000	1.136	-2.075	0.460	0.170	0.370	1.340
HP POST	1.933	1.238	1.052	1.132	-2.062	0.430	0.200	0.350	1.300
PC PRE	2.025	1.278	1.020	1.204	-1.775	0.430	0.180	0.360	0.990
PC POST	2.071	1.283	1.017	1.190	-1.681	0.400	0.190	0.380	1.120

Potentiation Report



Barbell Trajectory





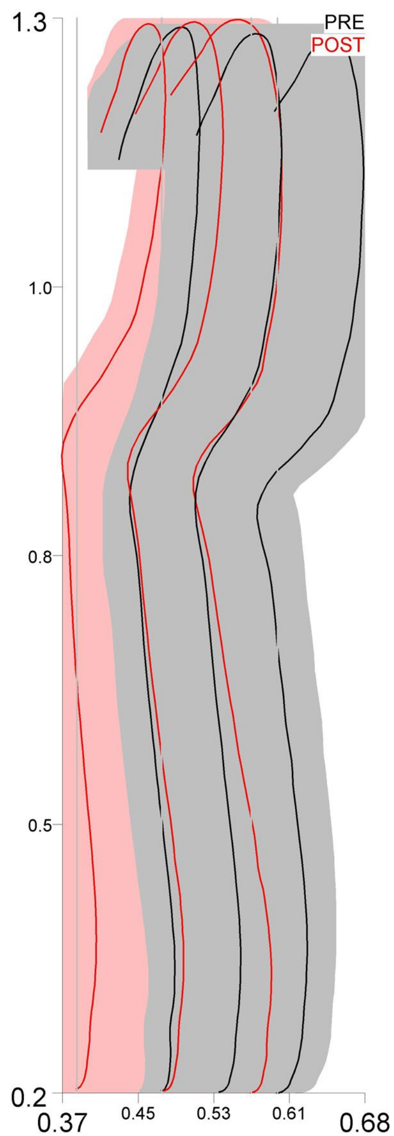
Type 4 **Type 3** **Type 2** **Type 1**

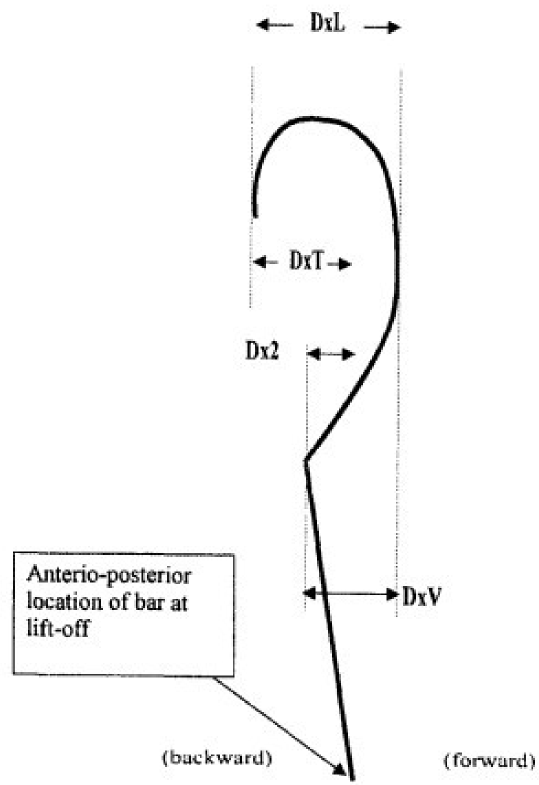
PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
PRE	1.842 ; 1.764	1.289 ; 1.300	1.015 ; 1.056	1.212 ; 1.162	-2.051 ; -2.057	0.600 ; 0.590	0.110 ; 0.120	0.390 ; 0.410	1.990 ; 1.400
POST	1.845 ; 1.714	1.308 ; 1.304	1.064 ; 1.084	1.229 ; 1.191	-2.124 ; -2.038	0.580 ; 0.600	0.120 ; 0.120	0.370 ; 0.380	1.850 ; 1.150

ANTERIOR POSTERIOR CHANGES

	PRE	POST
DxL: MOST FORWARD TO CATCH	-0.093 ; -0.084	-0.116 ; -0.067
DxT: START TO CATCH	-0.002 ; -0.044	-0.083 ; 0.026
Dx2: START TO START OF 2ND PULL	0.013 ; -0.018	-0.030 ; 0.005
DxV: 2ND PULL POSITION TO MOST FORWARD	0.078 ; 0.059	0.063 ; 0.088





LEGEND OF HORIZONTAL DISPLACEMENTS

(Lateral View)

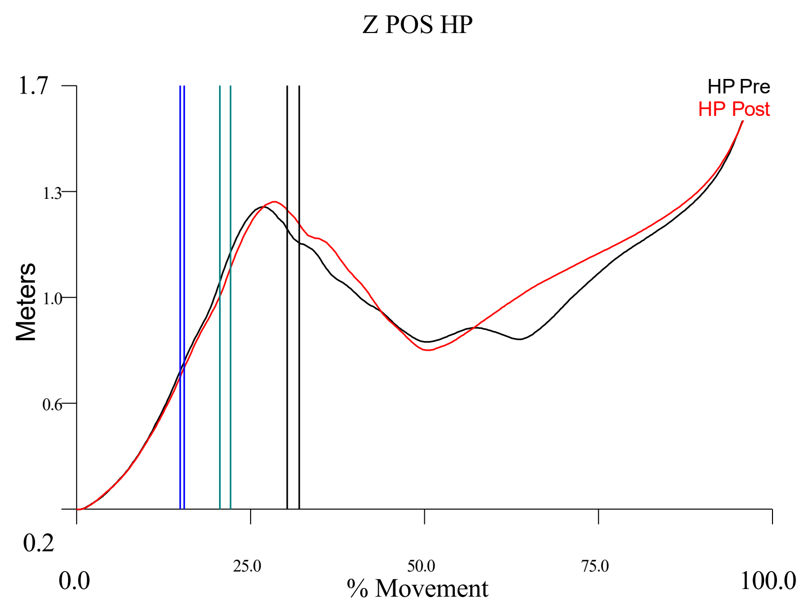
DxL = most forward position to catch

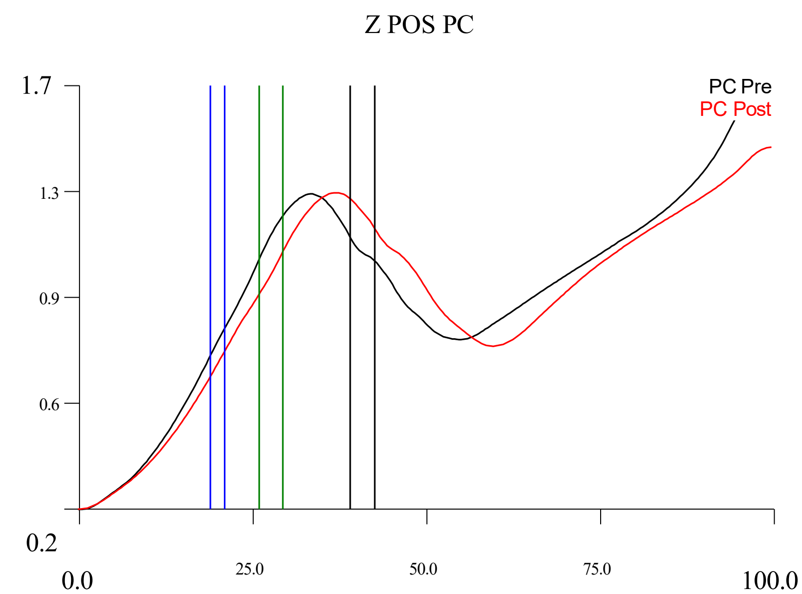
DxT = start position to catch position

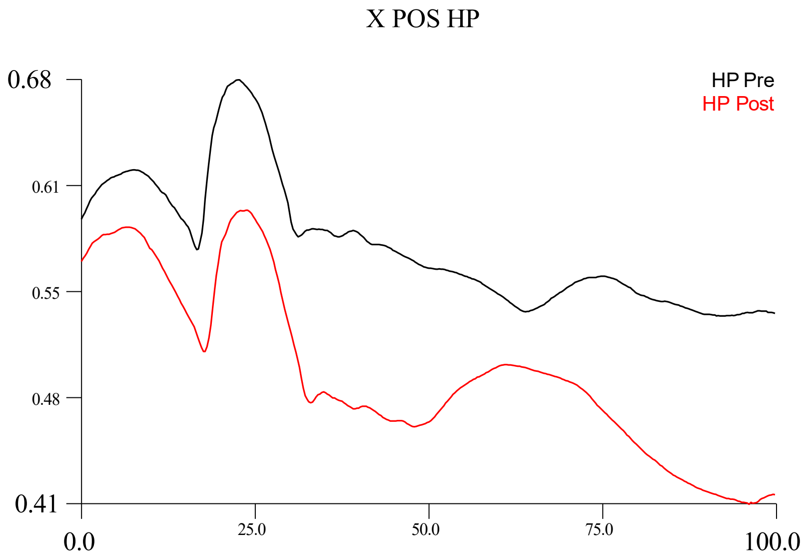
Dx2 = start position to beginning of 2nd pull

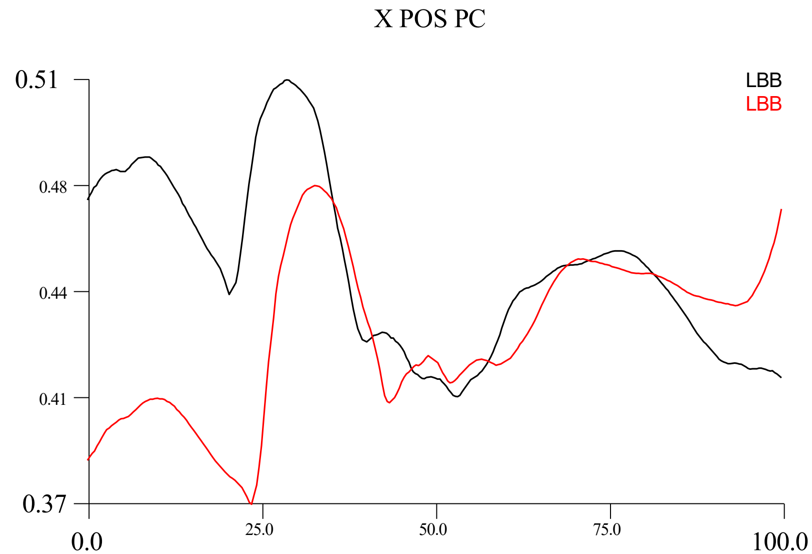
DxV = 2nd pull position to most forward position

ATHLETE Report



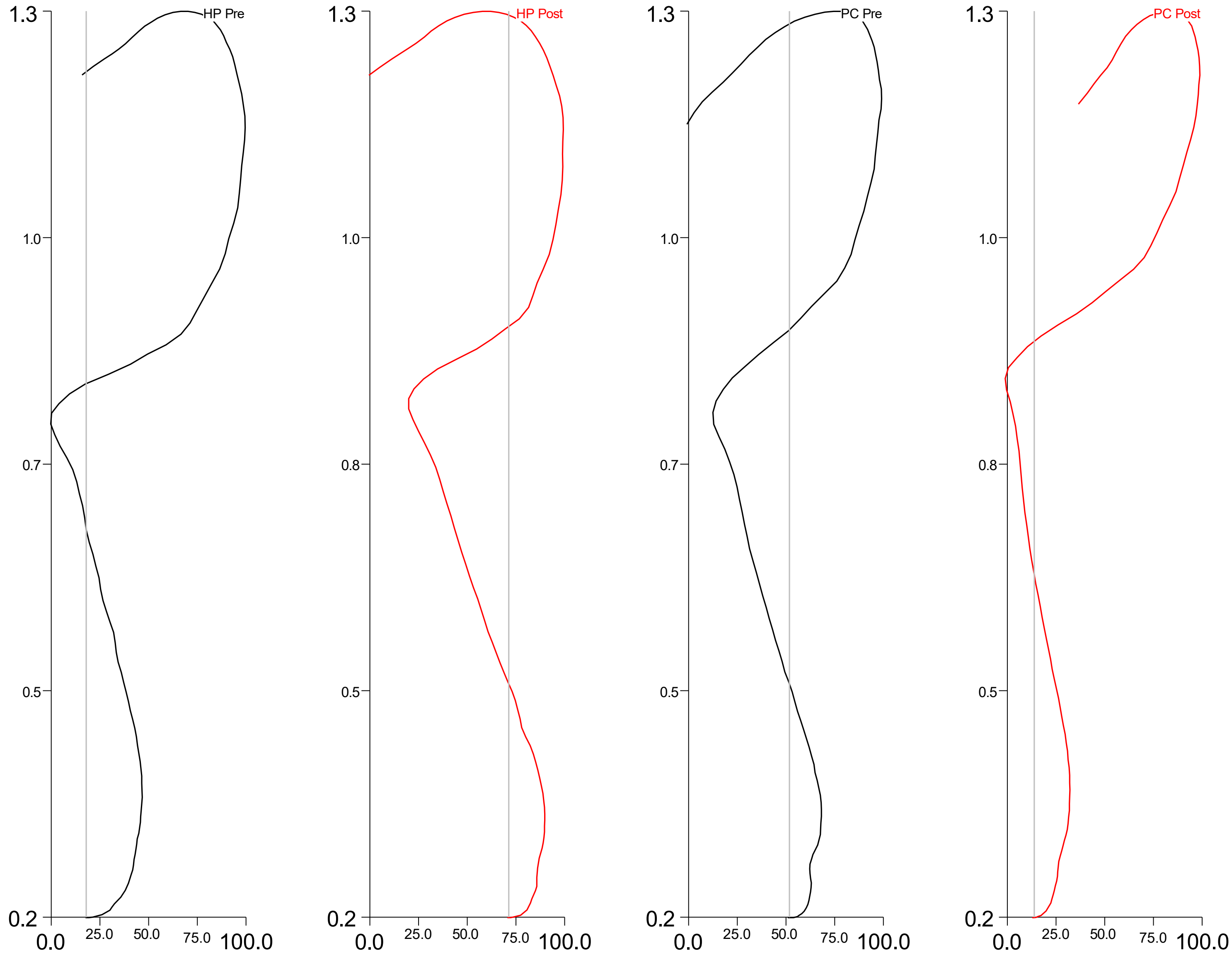






ANTERIOR POSTERIOR CHANGES HP VS PC

	PRE HP	POST HP	PRE PC	POST PC
DxL: MOST FORWARD TO CATCH	-0.093	-0.116	-0.084	-0.067
DxT: START TO CATCH	-0.002	-0.083	-0.044	0.026
Dx2: START TO START OF 2ND PULL	0.013	-0.030	-0.018	0.005
DxV: 2ND PULL POSITION TO MOST FORWARD	0.078	0.063	0.059	0.088



PRE VS POST METRICS

	MAX BB VELOCITY (M/S)	MAX BARBELL HEIGHT (M)	MAX BARBELL HEIGHT END OF 2ND (M)	BARBELL HEIGHT AT CATCH ONSET (M)	C7 VELOCITY IN TURNOVER (M/S)	1ST PULL DURATION (S)	2ND PULL DURATION (S)	TURNOVER DURATION (S)	RECOVERY DURATION (S)
HP PRE	1.842	1.289	1.015	1.212	-2.051	0.600	0.110	0.390	1.990
HP POST	1.845	1.308	1.064	1.229	-2.124	0.580	0.120	0.370	1.850
PC PRE	1.764	1.300	1.056	1.162	-2.057	0.590	0.120	0.410	1.400
PC POST	1.714	1.304	1.084	1.191	-2.038	0.600	0.120	0.380	1.150

VITA

LUKE T. DEVIRGILIIS

Education:	Ph.D. Sport Physiology, East Tennessee State University, Johnson City, Tennessee, 2024
	M.S. Sport Science and Coach Education, East Tennessee State University, Johnson City, Tennessee, 2021
	B.S. Health and Physical Activity, University of Pittsburgh, Pittsburgh, Pennsylvania, 2018
Professional Experience:	Director of Track and Field Athletic Performance, The Pennsylvania State University 2024
	Graduate Assistant, East Tennessee State University, Department of Sport Exercise Recreation and Kinesiology 2021-2024