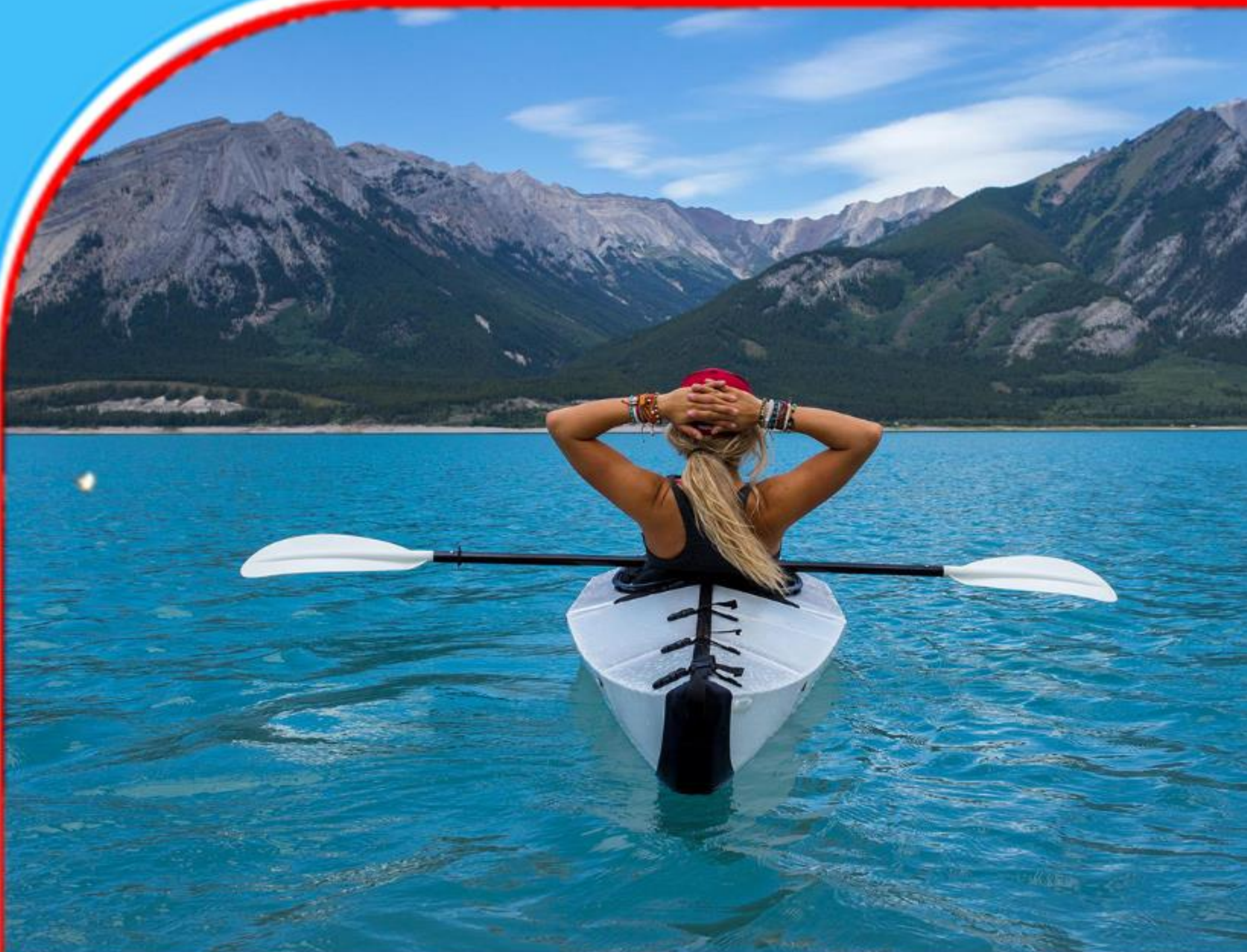
American Journal of
Recreation and Sports
(AJRS)



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AJPO

American Journal of Recreation and Sports
ISSN 2789-7046 (Online)
Vol.2, Issue 1, pp 1 – 28, 2023
www.ajpojournals.org

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Article history

Submitted 05.04.2023 Revised Version Received 19.04.2023 Accepted 07.05.2023

Abstract

Olympic Weightlifting is a sport where athletes of different weight classes utilize either the Snatch or Clean and Jerk (CJ) technique to lift the heaviest load overhead. This case study describes the training program for a team of Senior (age; 18-35 years) Olympic weightlifters during a normal competitive season. The team of Olympic weightlifters will be participating in team training 3 to 4 times a week; however, variations will occur on the training schedule for each individual athlete based on the on-going testing results. Each athlete will also participate in an additional day of training noted as the "active rest" day which prioritizes injury management for the individual based on their test results, during the training season. In conclusion, the training program in this study provided an insight on implementing velocity profiling into an Olympic weightlifting training program. The device in this study (PUSH Band) quantifies the bar movement via the force velocity curve and the coach has a clearer means in which to determine the repetitions that follow. This study is based around the theoretical idea of implementing a means in which to avoid the traditional periodization rep schema to administer training volume, but rather utilize new technologies. To conclude, methods that accommodate for velocity profiles to determine volume in conjunction with 1RM percentages and a coach's discretion may allow for more efficient training and a reduction in excess fatigue.

Keywords: *Olympic Weightlifting, Athlete, Snatch, Clean, Press, PUSH Band, Velocity Profiles*

1.0 INTRODUCTION

Olympic Weightlifting is a sport where athletes of different weight classes utilize either the Snatch or Clean and Jerk (CJ) technique to lift the heaviest load overhead. Bonini *et al* (2001) describes modern day Olympic Weightlifting as a sport which had been established in the 1880's in continental Europe. Olympic Weightlifting, originally popularized by the athlete Eugene Sandow, consisted of two lifts: The Snatch and Clean and Press. Dave Randolph (2015) stated that it was not until the 1940s and 1950s that Olympic Weightlifting adopted the CJ, the Snatch and the addition of the needle bearing styled barbells that we have today. In present day Olympic Weightlifting, the athlete attempts to lift the heaviest load overhead, with either what is known as the Snatch or CJ technique. Whitehead *et al* (2014) describes the Snatch as a lift which consists of 6 phases (start position, first pull, transition, second pull, catch and recovery) where the athlete attempts to lift a loaded barbell overhead in a single motion overhead motion. Dave Randolph (2015) describes the CJ as a technique as a 2 part lift; The Clean where the athlete lifts the loaded barbell to their shoulders and catching it just around the clavicle and the Jerk where the athlete lifts the barbell overhead in an explosive motion whilst splitting the legs into a semi-kneeling stance. However, the jerk also may have 3 different variations such as the Power and Squat Jerk. The Power jerk entails that the athlete thrusts the weight overhead whilst landing with slightly bend knees under the bar in the catch position, while the Squat jerk has the athlete performing a squatting motion similar to the Snatch under the weight.

During an Olympic Weightlifting competition, Athletes are given 3 attempts at both the Snatch and CJ techniques during, the course of a standard competition. Each athlete stands on stage in front of a loaded barbell and waits for an auditory beeping signal to lift the barbell with either of the techniques. During each attempt, once the barbell has passed the athletes knee, the loaded barbell may not move in a downwards motion again and the loaded barbell must continue in a steady upward motion. The athlete will then have to hold the loaded barbell overhead in a steady manner whilst waiting for the auditory and visual signal from the judges to drop the barbell. Any deviations from a strict upright standing position holding a loaded barbell will cause the athlete to miss their attempt. 3 attempts of each lift have taken place, the score total is then taken from the athlete's best lifts in both the Snatch and Clean and Jerk as well as their body weight to calculate the Sinclair formula which determines the standing of the athletes in the competition. Ford et al (2000) states that in 1993-1997 there were 19 body weight classes (males 54, 59, 64, 70, 76, 83, 91, 99, 108, 108+ kg and females 46, 50, 54, 59, 64, 70, 76, 83, 83+ kg) however in present day Olympic Weightlifting, there are only 15 weight classes for both sexes (males 56, 62, 69, 77, 85, 94, 105, 105+kg and females 48, 53, 58, 63, 69, 75, and 75+kg.)

Olympic Weightlifting is a highly explosive sport, meaning that the loaded barbell is lifted quickly in an aggressive manner. High degree of Type IIa fibers are necessary for optimum performance. Fry et al (2003) looked at the concentration of type IIa muscle fibres in Olympic Weightlifters by comparing 2 groups participants first a Weightlifter group (n=6, age 27+/- 2.1yrs, 936+/-44n bodyweight) and a Control group (n=7, age 22.0+/-2.0yrs, 752+/-45n bodyweight). During Fry *et al*'s (2003) study, only the Weightlifter group had experience with Olympic Weightlifting movements whilst the control group did not. Fry et al (2003) performed a muscular biopsies to determine the differences in muscular fibre type and protein expression characteristics between both groups, finding that the Weightlifter group exhibited a much higher percentage of type IIa muscle fibre types (% fibre type IIa 46.5+/-2.7, % fibre type areas 56.7 +/- 2.5 and % myosin heavy chain isoform 64.0 +/- 2.3) than the control group (% fibre type IIa 26.9+/-3.7, % fibre type areas 36.5+/-4.0 and % myosin heavy chain isoform 52.1 +/- 4.2). However, muscle fibre types such as the IIb showed higher results in the control group (% fibre type IIb 21.0+/-5.3, % fibre type areas 24.9+/-6.2 and % myosin heavy chain isoform 18.2+/- 6.1) than the Weightlifter group (% fibre type IIb 2.4+/-2.0, % fibre type areas 3.1 +/- 2.4 and % myosin heavy chain isoform 1.4+/-1.4). The results detailed the high dependence on type IIb muscular fibre types during the sport of Olympic Weightlifting. Due to the nature of the fibre type dependence displayed in Fry et al's (2003) study, it is best recommended to keep the training focused on improving the utilization of the Anaerobic Alactic energy system rather. However, Aerobic conditioning may be assumed to be useful regarding the reduction of work to rest ratios in Olympic Weightlifting.

Analyzing the movements kinematically, is predominantly done along the linear and vertical movement planes as seen in Akkus *et al*'s (2012) study and Gourgoulis *et al*'s (2000) study and in terms of musculature, the kinesthetic areas of movement in Olympic Weightlifting typically occur in the hip, knee and ankle joints. This is shown during the analysis of both Akkus et al (2012) and Gourgoulis et al's (2000) studies which quantified angular displacement in the hip, knee, and ankle joints, because of this it is noted that mobility and flexibility are needed in the ankles, hips, and shoulders due to the nature of the movements.

2.0 LITERATURE REVIEW

The training of Olympic weightlifting typically consists of short bouts of high intensity which stays within the range of the anaerobic Alactic energy system. This has been displayed with the elite Olympic weightlifters previously mentioned in Fry *et al*'s (2003) study as there is a high demand for type IIa fibre types while there is not an immediate need for type IIb, so it can be theorized from this information that aerobic fitness should have lower priority in implementing a training program for Olympic Weightlifting. Studies such as Hardee et al's (2012), examined the inter-repetition rest on power output during the performance of the power clean (PC) with recreational weightlifters (age 23.6 +/-0.4 years, weight = 788.4+/- 8.8n; height = 177.0+/-0.5 cm, weightlifting training age >1yr, total training age >4yrs) by having participants complete a protocol that consisted of a 1RM PC test for the first session, followed by a second session of 3 sets of 6 repetitions with 80% of the 1RM PC from the previous session at intervals of 0 (P0), 20 (P20) and 40 (P40) seconds inter-repetition rest (IRR) periods with a total of 3 minutes rest between sets, using peak power (pp), force and velocity as performance indicators. It was found during the study that the P0 IRR periods resulted in a lower change of pp (−7.51+/-1.39%), force (−3.41 ± 0.72) and velocity (−5.71 ± 0.42%) compared to the P20 (pp −2.56+/-1.31%, f -1.14+/-0.68%, v -1.85+/-0.48%) and P40 (pp−1.81+/-0.91%, f +0.20+/-0.83%, v -0.91+/-0.33%) groups.

The relationship between these factors during this study provide an insight to how different IRR ratios can affect the indicated performance factors of the participants during this study as the longer rest periods demonstrated the maintenance of pp, f and v during the PC performance of each participant. Concluding from this study, it's recommended to stay within the anaerobic Alactic energy system whilst determining the appropriate rest ratios as it would be the most beneficial to the adherence of sport specificity in administering the training program of an Olympic weightlifter. Quantification of factors can be done via monitoring the sport's primary stimulus which is the weighted barbell and with this in mind, Olympic weightlifting can be described as a very apparent combination of Newton's 3 laws in terms of analyzing the barbell path, displacement and trajectory during the lifts. This has been shown during studies which consider the kinematic analysis of Olympic weightlifting such as Akkus *et al* (2012) and Gourgoulis et al's (2000) study. Newton's Second Law specifically demands attention in the actual mechanics of weightlifting. To reiterate the second law; "The relationship between an object's mass (m), its acceleration (a) and the applied force (f) is F = ma". The loaded bar in each of the main lifts in Olympic Weightlifting is the mass (ma) which acceleration (a) and applied force (f) must act upon to be moved. The velocity (v) of which the loaded barbell is displaced during an Olympic weightlifting movement a necessary component when quantifying the athlete's ability to accelerate different amounts of mass and how much force can be applied.

Velocity and athletic performance have been examined in other sports as well to determine their relationship to each other. However, in the sport of Olympic weightlifting, performance indicators can be quantified through either the movement of the barbell or the athlete's kinematics during each phase of both the snatch and CJ. Studies, such as Isaka *et al* (1996) utilized videography to quantify this relationship in terms of barbell displacement and velocity in regards, to athletic performance when examining the second pull phase of both the snatch and the clean. During this study, Isaka *et al* (1996) implemented what was noted as the Video-Tracker System to track the vertical and horizontal velocity of the bar path during the snatch to determine the afore-mentioned variables (f, m and v) to determine this relationship. Using the Video-Tracker System, Isaka *et al* (1996) examined the difference in characteristics of the Chinese men's national weightlifting team between elite athletes (n=6, age 26.33yrs, weight 675+/-1.4n, snatch 1528.17+/-20.98n) and sub-elite athletes (n=6, age 21.33+/-1.37yrs, weight 672.93+/-1.66n, snatch 1431.77+/-40.2n) and the different phases of the Snatch; M1 start position, M2 instant of knee angle, M3 maximum vertical rising velocity, M4 maximum vertical falling velocity and M6 ending of the squat to standing position. During Isaka et al's (1996) study, a significant difference was found in the maximum vertical acceleration of the barbell during the M3 portion of the snatch between both groups of the elite 4.59+/-0.85m·s−2 to sub-elite 2.99+/-1.01m·s−2 Olympic weightlifters. Another notable difference between both groups when considering the vertical linear velocity of the barbell was the difference in the M1 phase which saw 1.05+/-0.11 m·s−1 in the elite group and 0.71+/-0.20m·s−1 in the sub-elite group, however during the M2 phase of the snatch it was found that the elite group (1.72+/- 0.07m·s−1) displayed higher results in comparison to the sub-elite group (1.00+/-0.18m·s−2).

Similarly the study found the same results when examining the M3 (elite 1.74+/-0.10, sub-elite 1.44+/-0.28) and M5 phase (elite -0.73+/-0.11m·s−2, sub-elite -0.56+/-0.18m·s−2). Concluding from the data in the analysis, it seems that a determinant of performance when comparing the differences between elite and sub-elite lifters in terms of velocity is velocity during the M1 first position to the M2 position, which the sub-elite lifters statistically move the bar faster and theoretically exert more energy before proceeding to the M2 phase and so on. It can be concluded from these results that in the training of a competitive Olympic weightlifter, a key performance indicator on the snatch would be the velocity during the afore-mentioned phases of the lift, specifically the speed from the first phase to the knee (M1 to M2). Jose Campos *et al* (2006) also examined the barbell velocity during each phase of the snatch lift using a 3- dimensional photogrammetry technique with elite junior male weightlifters (n=33). The participants during this study were divided into 2 groups based on weight classes; Group A 56- 62kg (weight 577.8+/-30n) and Group B 85-105kg (weight 897.7+/-92.6n) and the snatch lift divided into phases (T1-T2 First Pull, T2-T3 Transition, T3-5 Second Pull, T5-T6 Turnover, T6-T7 Catching, T7-T8 Absorption). Similarly, to Isaka et al's (1996) study it was found velocity peaked during the First Pull and Second Pull phases of the snatch lift. Another study, completed by Sato et al (2012) assessed the reliability of measuring weightlifting performance through tracking a barbell's acceleration and path with the use of a portable triaxial accelerometer (PS-2119, Pasco Scientific, Roseville, CA, USA) attached to a Bluetooth wireless device (Pasco Passport Airlink SI (PS-2005) and a group of nationally ranked weightlifters (Males; n=7, age 23.0+/-3.2, weight 961+/-235n, training age 7.3+/-1.7 years. Females age n=5, age 20.0+/-1.4, weight 704+/-163.77n, training age 5.8+/-1.1 years), over the course of three training sessions days (80%, 85% and 90% per each day of the athlete's recorded official competition 1RM). The portable device (Triaxial accelerometer and Bluetooth wireless device) were attached to the side of the barbell and compared to previous reports of a high speed camera set at the same sampling rate of 100hz to determine reliability in the tracking of acceleration and bar path.

Sato *et al* (2012) determined that over the course of multiple testing days, the peak barbell acceleration resulted in a test-retest ICC reliability of r=0.88 (95% CI 0.81-0.93). Hamill *et al* (1994) performed a survey on competitive Olympic weightlifters (n=560) to find the injury rates during participation. It was reported that the Olympic weightlifters (n=560) only reported 2 total injuries (1 serious injury, 1 other) over their total participation hours (25,190) which lead to a significantly low rate of injury (0.0013) per 100 hours of participation. Hamill et al (1994) also found an even lower rate of injury (0.0017) per every 100 hours (168,551 total reported hours) in the systematic review of other studies. Calhoon *et al* (1999) used a smaller subset sample size (n=27) of Olympic weightlifters to view the rate of injury incidence by viewing the training records to determine total hours and also gathered the total number of injuries made by reported incidents. A much higher injury was found at 3.3 incidents per 1000hours (0.033 per 100 hours compared to 0.0013-0.0017 from Hamill *et al* (1994)).

Engebretsen *et al* (2012) gathered data on Olympic weightlifters (n=252) using a survey to create reports on the injuries and illnesses sustained over the course of the 2012 London summer Olympic Games. Out of the total (n=252) athletes that were surveyed, only 17% (n=44) confirmed injuries or illnesses. It was found that number of injuries sustained during training (n=22 (50% of total injuries)) were similar to that during competition (n=18 (45%)) and illnesses accounted for a small number (n=10(4%)) of the total reports. Out of these injuries, a higher number (n=19(48%)) returned to training in >1day and a lower number (n=11(25%)) did not return to participation <1day until >7days. Calhoon *et al* (1999) gathered data on (n=560) reported injuries in elite Olympic weightlifters over the course of 6 months of training. In comparison a similarly higher percentage of athletes returned to training <1day (n=507(90.5%)), and in <1week (n=48(8.6%) compared to <3wk n=2(.4%) and >3wk n=3 (0.5%)) than in the data found by Engebretsen *et al* (2012). Calhoon *et al* (1999) categorized the injuries of (n=560) weightlifters into the locations of their injuries (Low back, Knees, Shoulders). Calhoon *et al* (1999) found that low back (n=130) and knees (107) accounted for the largest number of injuries in the total population (n=560) with shoulders coming in last (n=99). Out of the total lower back injuries (n=157), acute injuries (n=92) consisted of a significantly higher percentage of total injuries in that location compared to chronic (n=49) and other causes (n=16), in addition a large number of these cases consisted of a strain type injury (n=97).

Although the total number of Knee injuries (n=107) undergo only slightly more chronic injuries (n=51) in comparison to acute (n=41) and other causes (n=15), a large number of injuries result in a chronic condition like tendinitis (n=91) compared to strains (n=7) and other (n=9). In the total number of shoulder injuries (n=99) a large number were acute (n=67) and chronic (n=25). The 252 Olympic weightlifting athletes that Engebretsen *et al* (2012) looked at during the summer Olympic games which accounted for a total of 44 injuries which occurred in the lower back (n=7), knee (n=6), shoulder (n=5) and elbow (n=10) which accounted for the highest amount of injuries compared to other categories such as hand (n=1) and sternum (n=3). Out of the total injuries a high number of them occurred due to a sprain or muscle tear (n=15) and a strain or rupture (n=11). The largest amount of these cases being a result of non-contact trauma (n=11), sudden (n=11) or gradual overuse (n=4) and a recurrence of previous injury (n=4). In this study only 1 reported case saw an injury due to the field of play conditions (n=1), contact with a moving object (n=2) or equipment failure (n=1).

In terms of the knees, Kujala *et al* (1995) took 29 former elite Olympic weightlifters (Age range 46-66, 56.5+/-5.7) and used a survey in addition to radio graphical measurements to determine the risk or severity of existing cases of knee osteoarthritis. The two largest results of knee injuries in the 29 reported cases were Knee osteophytes (n=10 reports), Extension deficiency (n=10), Knee osteoarthritis, Patellofemoral osteophytes (n=9) and Patellofemoral osteoarthritis (n=8) while a low number had been due to conditions such as Cysts (n=2). In terms of the shoulders, Gross et al (1993) took 20 Olympic weightlifting athletes during rehabilitative treatment of their shoulders (23 shoulders treated). It was found that (n=20) of athletes experienced pain when the shoulder was forcibly abducted or externally rotated, as well as the inability to perform on tests requiring an abducted and externally rotated shoulder. Half of the athletes (n=10) returned to play <7days following non-invasive treatment, while the other half (n=10) returned after surgical treatment. Scavenius *et al* (1992) looked at the risk of impact injury to the clavicular osteolysis in 25 Olympic weightlifters in comparison to 25 general population individuals using radiographic examination of both shoulder joints. In the Olympic weightlifter group only a few (n=7) cases of classical radiographic clavicular osteolysis while an even fewer (n=4) group had subjective symptoms relative to the condition in comparison to the other group which displayed no symptoms in any participants. There are less prevalent injuries such as a tearing of tricep muscles such as in Sollender et al's (1998) study which found 4 cases of Olympic Weightlifters who have experienced a triceps tendon rupture to find that all of these athletes were confirmed to be dosing steroids. It was found that none of the cases took place during the practice of Olympic weightlifting, but rather the participants in that population (n=3) had been injured while bench pressing heavy weights. Miller et al (1996) found 3 cases of lunate dislocation during Olympic weightlifting movements. A single 22-year-old male dislocated their lunate during the receiving phase of a missed clean lift, the elbow struck the knee which caused an acute dorsiflexion at the wrist causing the lunate to dislocate and general pain in the area.

A way of measuring mobility and flexibility are Goniometric Measurements which entail that the tester measures the range of motion per each joint of the human body which can highlight potential areas at risk of injury. Measuring goniometrics is a method of quantifying range of motion relative to the participants' movement. These measurements can include the range of motion around the axial of the ankle or elbow joint at each degree of flexion. Studies such as Gogia *et al* (1987) quantified the flexion of the knee with healthy subjects (n=30, 40+/-20yrs), via goniometric measurements whilst positioned on their right side lying on a roentgenographic table and placing their lower left extremity on a stabilizing board, elevated 15cm above the table's surface. To standardize the testing position of each participant, the tester placed the posterior aspect of the subject's left thigh in contact with two 15cm pegs which were inserted perpendicularly onto a stabilizing board, then the left leg of the participant was moved to measure the angle of the knee joint in the intended position.

Once the left leg of the participant was placed into the required angle, the next group of testers (two physical therapists) were then instructed to measure the angle using a plastic goniometer at the knee joint of the sagittal plane, utilizing skeletal landmarks such as the greater trochanter to the lateral condyle of the femur and the head of the fibula to the lateral malleolus. During Gogia et al's (1987) study, it was found that the goniometric testing of the knee displayed high values relating to intertester reliability (r=.98; ICC = .99) and validity (r =.97-.98; ICC = .98 - .99). Goniometric testing is a means in which to efficiently gauge the mobility and flexibility of a participant during a training program with clear status markers.

Another convenient method of monitoring participant fatigue that is modifiable in terms of purpose is the Borg Rate of Perceived Exertion (RPE) Scale which is a scale that allows participants to self-report their level of fatigue of during or after exercise in a convenient manner. It was originally invented by Dr. Gunnar Borg in (1982) as a scale which quantified fatigue based on a rating from 6 to 20. The original Borg RPE scale then was reduced in a later study by Borg et al (1970) to the 15-factor RPE scale then again in 1985 by Dr. Borg Gunnar and lastly to the CR 10 scale in 1998 which quantified similar factors using a lower numerical value (0-10) as seen on the original version. On the original 20-factor Borg RPE scale, the lowest score of 6 can be equivalent to no activity or akin to physical and mental dormancy, whereas a rating of 20 would equate to a dynamic or explosive phase of exercise such as the Snatch in Olympic Weightlifting. The scale has also been adapted depending on the individual coach's implied needs, a few methods relating to this includes the session-RPE (sRPE) which gauges the athletes RPE per each individual session and adjusting the quantifiable numerical factors which may range from either 0-5 or 0-7. In addition, the Likert scale is often used to determine the athlete's fatigue status during the survey (Not Satisfied to Very Satisfied, 0-5). Haddad et al (2017) performed a meta-analysis on several studies which quantified the validity and reliability using when the RPE scale to determine its correlation, significant and confidence interval (ICC 95%) scores when compared to several values, specifically 1RM ($p<0.05$, ICC 95% of $\mu 0.88$ and $\mu 0.095$), sRPE (r=073-0.94), Anaerobic volume (r=0.35), high intensity volume (r=0.45) and accelerations >3 m/s^2 in soccer (r=0.37).

Strategic Plan Overview

This case study describes the training program for a team of Senior (age; 18-35 years) Olympic weightlifters during a normal competitive season. The team of Olympic weightlifters will be participating in team training 3 to 4 times a week; however, variations will occur on the training schedule for each individual athlete based on the on-going testing results. Each athlete will also participate in an additional day of training noted as the "active rest" day which prioritizes injury management for the individual based on their test results, during the training season.

Athlete Profile

- Team Size: 16-32
- Ages: 18-35
- Training Age: <3-4 yrs.
- Height: 125-225cm
- Weight: 56-105+kg

Timeline

Table 1: Competition Schedule

Date	Name	Hosting Club	Location	Quest for Gold Qualifier	Type
3/28/2020	Ontario Classic Elite	CrossFit NCR	Ottawa	Yes	Open
3/29/2020	Ontario Scholastic Challenge	Norsemen and Valkyries	North Bay	No	Academic
4/4/2020	Feats of Strength	STAVE OFF Barbell Club	Kingston	No	Open
4/4/2020	Canadian Senior Championships	Toronto Weightlifting	Scarborough	Yes	Championship
6/13/2020	Toronto Cup	Toronto Weightlifting	Scarborough	Yes	Championship
8/22/2020	Summerfest	Toronto Weightlifting	Scarborough	Yes	Open
9/12/2020	Hybrid Open	London Weightlifting	London	Yes	Open
9/19/2020	Bay of Quinte Open	Adamantium	Belleville	Yes	Open
9/20/2020	Ray Hamilton	Norsemen and Valkyries	North Bay	No	Academic
10/10/2020	Radix Barbell Qualifier	Radix Barbell	Oakville	Yes	Open
11/07/2020	Ontario Championships Elite	Sheridan College	Brampton	Yes	Championship
12/05/2020	Junior Ontario Championships	Variety Village	Toronto	Yes	Championship
12/12/2020	Mistletoe Challenge	Toronto Weightlifting	Scarborough	Yes	Open
12/19/2020	Holiday Open	Adamantium	Belleville	Yes	Open

Table 2: Yearly Macrocycle

Phase	Date (From)	Date (To)	Competition(s)
Off-Season	01/25/2020	02/15/2020	
Hypertrophy	02/15/2020	03/28/2020	
Strength	03/28/2020	04/02/2020	Ontario Classic Elite
Peak	04/02/2020	05/30/2020	Canadian Senior Championships
Off-Season	05/30/2020	06/27/2020	
Hypertrophy	06/27/2020	07/25/2020	
Strength	07/12/2020	09/17/2020	Radix Barbell Qualifier
Peak	10/17/2020	11/14/2020	Ontario Championships Elite
Off-Season	12/14/2020	01/25/2021	

Table 3: Per Phase Details

Phase	Average Percentage of 1RM	Rep Range	Priority via FVC Profile	Duration per Session (Minutes)	Duration (# of weeks)	Training Priority
Off-Season	55-65%	8-12	Speed	30-45	2-4	Injury Prevention and Flexibility
Hypertrophy	65-75%	6-8	Speed Strength	45-60	6-8	Muscular Endurance and Mobility
Strength	75-85%	2-5	Maximal Strength	45-90	4-6	Muscular Strength and Stability
Peak	85-95%	1-3	Strength Speed	60-90	2-4	Technique and Power Production

Table 4: Testing Schedule

Type	Frequency	Methods
PAR-Q	Per-Phase	Mandatory
Goniometric Measurements	2x Per-Phase	Goniometrics
Rate of Perceived Exertion	Post-Session	Self-Report
Athlete Diary	Daily	Self-Report

2.0 METHODOLOGY

Warmup Protocol

The warmup protocol consists of 3 separate but interchangeable circuits based on the coach's perception of the athlete's needs.

Warmup A:

- 5x10:20 rounds Assault Bike
- Lying Side Leg Raise
- Hanging Scapular Retractions

Warmup B:

- 2x250m Row Machine
- 2x rounds of 10x Front Leg Swings (per leg)
- 2x rounds of 10x Side Leg Swings (per leg)

Warmup C:

- 4x10m Broad Jumps
- 4x10m Each direction X-band walks
- 4x10 Banded Pull-Apart

Cooldown Protocol

The cooldown protocol consists of 3 separate but interchangeable circuits based on the coach's perception of the athlete's needs.

Cooldown A:

- Kneeling Hamstring Stretch

- Kneeling Quadricep Stretch
- Pigeon Stretch

Cooldown B:

- Seated Groin Stretch
- 90/90
- Lying Shoulder Stretch

Cooldown C:

- Pigeon Stretch
- Dowel Rotator Stretch
- Leaning Scapula Stretch

Off-Season Phase

During an off-season phase workout, the athlete will complete 4 workouts a week. An example of a workout during the off-season phase;

Table 5: Off-Season Phase

Class	Movement	Variation	Notes
Sport Specific Movement	Power Clean	N/A	Optional, Reduced Loading
	Power Jerk	From Rack	Optional, Reduced Loading
Strength Movements	Bench Press	N/A	Optional, Reduced Loading
	Front Squat	N/A	Optional, Reduced Loading
Assistance Movement	Pull	Bicep Curl	Dumbbell
	Push	Tricep Extension	Cable
Torso	Stability	Bird-Dog	Circuit
	Stability	Dead-Bug	Circuit

Each workout will consist of;

- 2x Optional Sport Specific Movement(s)
- 2x Optional Strength Movement
- 2x Assistance Movement
- 2x Torso Movements

Hypertrophy Phase

During a hypertrophy phase workout, the athlete will complete 4 workouts a week. An example of a workout during the hypertrophy phase;

Table 6: Hypertrophy Phase

Class	Movement	Variation	Notes
Sport Specific Movement	Power Snatch	N/A	Complex
	Overhead Squat	N/A	Complex
	Full Snatch	N/A	
Strength Movement	Back Squat	N/A	
Assistance Movement	Pull	Latissimus Pull-Down	Tempo
	Push	Dumbbell Row	Tempo
	Pull	Hanging Retraction	Tempo
Torso	Stability		Circuit
	Stability		Circuit

Each workout will consist of;

- 2x Sport Specific Movement(s) completed as a Complex
- 1x Sport Specific Movement
- 1x Strength Movement
- 3x Assistance Movements
- 2x Torso Movements completed as a Circuit

Strength Phase

During a strength phase workout, the athlete will complete 3 strength-oriented workouts a week and an additional workout. An example of a strength-oriented workout during the hypertrophy phase;

Table 7a: Strength Phase

Class	Movement	Variation	Notes
Sport Specific Movement	Power Clean	N/A	
	Hang Clean	From Blocks	
Strength Movement	Military Press		Extended Break
	Front Squat		Extended Break
Assistance Movement	Pull	Hanging Scapula Retraction	
Torso	Stability		Circuit
	Stability		Circuit

Each workout will consist of;

- 2x Sport Specific Movement
- 2x Strength Movement
- 1x Assistance Movement
- 2x Torso Movements completed as a Circuit

An example of the additional workout during the Strength phase;

Table 7b: Strength Phase

Class	Movement	Variation	Notes
Sport Specific Movement	Snatch	N/A	Weekly 3RM
	Clean and Jerk	N/A	Weekly 3RM
Strength Movement	Back Squat		Weekly 5RM
Assistance Movement	Tricep	Cable Pushdown	Reduced Loading
	Back	GHD	Reduced Loading
Torso	Stability		

Each workout will consist of;

- 1x Snatch up to weekly 3RM
- 1x CJ up to weekly 3RM
- 1x Strength Movement up to weekly 3RM
- 2x Assistance Movements with Reduced Loading
- 1x Torso Movement

Peak Phase

During a strength phase workout, the athlete will complete 3 strength-oriented workouts a week and an additional workout. An example of a strength-oriented workout during the hypertrophy phase;

Table 8a: Peak Phase

Class	Movement	Variation	Notes
Sport Specific Movement	Hang Snatch	From Blocks	
	Full Snatch		
Strength Movement	Back Squat	Paused	Reduced Load
Assistance Movement	Pull	Banded Pull-Apart	
Torso	Stability		

Each workout will consist of;

- 2x Sport Specific Movement
- 1x Strength Movement up to 85%
- 1x Assistance Movement
- 1x Torso Movements completed as a Circuit

An example of the additional workout during the peak phase;

Table 8b: Peak Phase

Class	Movement	Variation	Notes
Sport Specific Movement	Snatch	N/A	Weekly 1RM
	Clean and Jerk	N/A	Weekly 1RM
Strength Movement	Back Squat		Weekly 3RM
Assistance Movement	Tricep	Cable Pushdown	Reduced Loading
	Back	GHD	Reduced Loading
Torso	Stability		

Each workout will consist of;

- 1x Snatch up to weekly 3RM
- 1x CJ up to weekly 3RM
- 1x Strength Movement up to weekly 3RM
- 2x Assistance Movements with Reduced Loading
- 1x Torso Movement

Methodology Justification

Testing Protocols

Physical Activity Readiness Questionnaire (PAR-Q):

National Academy of Sports Medicine (NASM) Guidelines are placed as a mandatory preliminary questionnaire to the start of the training program to ensure the health, safety and fulfill the legal obligation of the coaches as a service provider.

Goniometric Measurements

Goniometric measurements are placed into the testing portion of the program at the beginning and end of each phase to ensure that each athlete's mobility and flexibility are accounted for during the training session. In addition, the coaches have a recorded profile of the athlete's status in these regards, which to change or implement training modalities to ensure further success. Goniometric measurements are put in place to reduce injury risk and allow the coaches insight on how to adjust the program regarding the individual needs of the athlete.

The scoring system of the goniometric measurements as mentioned before

Rate of Perceived Exertion (RPE) Survey

The RPE survey is a means to gauge the athlete fatigue during the training program. The RPE survey will be administered via a survey on the athlete's cell phone post-workout every training session. For this program, the PUSH Band Portal application will be used to keep costs down, the adherence to a single place to input and store athlete data.

Athlete Diary

The Athlete Diary is a means for the athlete to self-report their mood status, health and sleeping habits during the training program. The athlete diary also allows for the athlete to have additional input into their own training which can be adjusted at the coach's discretion.

PUSH Band

The PUSH band was implemented as the primary means to quantify velocity in comparison to other devices which are used to determine the FVP. This is due to the wireless capabilities of GPS and accelerometer-based devices in comparison to the string-based style T-force linear transducer devices. Balsalobre-Fernandez et al (2016) analyzed the reliability and validity of the PUSH wearable device in comparison to a T-Force linear transducer (LT) to measure velocity with 10 healthy men (ages; 23.4+/-5.2 years; 1RM back squat 813+/-80n) on the smith machine, performing 3 repetitions at 5 different loads (25-85%) with the back squat.

Balsalobre-Fernandez et al (2016) found that during this study, both of these devices displayed a high agreement (ICC = 0.907) and both devices showed similar high test-retest reliability (LT; r=0.98, ICC 0.989, PUSH; r=0.956, ICC =0.981).

Warmup Protocol

The warmup protocol consists of 3 separate but interchangeable circuits based on the need's analysis set forth by the goniometric test scoring. The prescribed warmup protocol will be administered to all athletes; however, exercises will be interchanged in relation to the area of movement based on the athlete's individual goniometric results at the beginning of the phase.

Cooldown Protocol

The cooldown protocol consists of 3 separate but interchangeable circuits based on the need's analysis set forth by the goniometric test scoring. The prescribed warmup protocol will be administered to all athletes; however, exercises will be interchanged in relation to the area of movement based on the athlete's individual goniometric results at the beginning of the phase.

Off-Season Phase

Volume for training will be prescribed along the Force-velocity curve as described by Suchomel et al (2017) study in table 1. During the Off-season phase, each athlete will have the option of coming into the training facility to complete the 4 movements listed at the start of the workout. If not, the athlete may finish the workout at their leisure then self-report on their RPE survey to maintain standard fitness levels. The athlete will be required to participate in at least one Active Rest day per week. An Active Rest day may consist of any of the following physical activities; casual team sports (soccer, basketball, etc.), swimming, cycling or otherwise.

Hypertrophy Phase

Volume for training will be prescribed along the Force-velocity curve as described by Suchomel et al (2017) study in table 2 and 3. The Hypertrophy phase consists of 2 Sport Specific movements at the start of the workout done in a Complex then a Sport Specific move based on the foundations set in the previous 2 exercises. A complex styled fashion consists of completing both movements together as a set with an adjustment made on the repetitions based on the Force Velocity Profile. The Strength movement will have a reduced loading to place an emphasis on the 3 assistance exercises. The tempo of the 3 assistance exercises will be modified over time.

Strength Phase

Volume for training will be prescribed along the Force-velocity curve as described by Suchomel et al (2017) in table 4. The Strength phase consists of 2 Sport Specific movements at the start of the workout done followed by 2 Strength movements based on the previous 2 exercises per each individual workout with an emphasis on the strength class movements. The emphasis during this phase will be on the Strength based movements.

Peak Phase

Volume for training will be prescribed along the Force-velocity curve as described by Suchomel et al (2017) in table 5. During a Peak phase, the training program will prioritize the technique and FVP of the sport specific movements. Additional rest time between sets and total session time will be given during workout to prioritize the FVP of the individual athlete.

Resources

Staff

- 1 Coach
- 1 Program Manager

Equipment

Table 9: Training Equipment

Type	Quantity	Dimensions or Weight (If applicable)	Additional
Barbell Women's 15kg	8	Total length; 2010mm, grip diameter; 25mm, sleeve diameter; 50mm	IWF Standard - Needle-Bearing
Barbell Men's 20kg	8	Total length; 2200mm, grip diameter; 28mm, sleeve diameter; 50mm	IWF Standard - Needle-Bearing
Collars 2.5kg	32	Inner diameter; 50mm	IWF Standard – Chrome, locking ring
Weight Sets	16	Inner diameter; 50mm, 190kg set of pairs; 50,20,15,5,2.5,2,1.5,1,0.5kg	IWF Standard – Competition Style, Rubber
Platform	16	Size; 2500(length)*2500mm(width)	Wood center, rubber exterior.
Bench	16	Size; 1320*605*440mm(height)	Foam covering, moisture wicking
Rack	8	Size; 1990*1865*2400mm	Pull-up bar included
Squat Stand	8	Size; 702*1310*1110mm	
Adjustable Jerk Box	16	Size;1050*550*500-2500mm	Rubber surface
Adjustable Pull Box	16	Size;1050*550*100-500mm	Rubber surface
Plyometric Box Sets	8	Size;620*620*450,600,750,900*mm	Set of 4 foam-covered boxes
Glute Ham Raise	8	Size; 1535*700*1275mm	Length adjustable
Pulley System	8	Size; 1500*610*2500mm	Bars included; Latissimus pull- down, T-bar row, single hand, tricep rope, neutral grip.
Assault Bikes	8	Size; 1293*592*1229mm	Moisture wicking seats
Loadable Dumbbells	15	Sleeve diameter; 50mm. Pairs of weights; 12x5, 4x2.5, 4x1.5kg	2x spring collars per set
Dumbbell Rack	3	Size; 2304*685*680mm	Dumbbell storage per tier *10
Foam Roller	32	>900mm	Foam based, tube shape
Chalk Holder	8	Size; 508*977mm, Diameter; 345mm	Standing chalk container with wheels
Chalk	64	125 microns grain size	Box of 8 Blocks

Table 10: Testing Equipment

Type	Quantity	Dimensions (If applicable)	Additional
Computer	1	>5 core processor, >1.8ghz, >250gb Solid state disk (SSD) storage capacity	Laptop preferred with PUSH Band software installed
Cell Phone	16-32 (per athletes)		With PUSH Band App installed
Goniometer	1-2	360° Rotation, 1° Increments	Steel, Extendable Arms
PUSH Band	16-32 (per athlete)	Sizing; Small 2200mm, Large 2900mm	
Dowel	16	Size; 2200mm, diameter; 28mm	Wooden or Aluminum
Dowel	16	Size; 2010mm, diameter; 25mm	Wooden or Aluminum
Weight Scale	1	Size; 450*600*100mm	Electronic, calibrated to 20gr

Facility

Detailed list of minimum space required per each prioritized piece of equipment and the total facility space required. Formulas are based off the NSCA Essentials of Strength and Sport Conditioning (Page 630; Table 23.1, Page 631; Table 23.2).

Table 11: Facility

Area	Equipment	Quantity	Formula	Total Space Required
Olympic Weightlifting Area				
Platform		8	3000(length)+1000mm (safety space) * 2500mm(width)+1000mm (safety space)	96,000mm²
Strength Area				
Rack		8	2000(bar length) +2000mm (safety space) * 3000mm (safety space)	96,000mm²
Platform		8	3000(length)+1000mm (safety space) * 2500mm(width)+1000mm (safety space)	96,000mm²
Bench		8	2000(length)+1000mm (safety space) * 2000mm(width)+1000mm (safety space)	90,000mm²
Free Weight Area				
Dumbbell Rack		3	2304*685mm*3 dumbbell racks	1,578,240 mm2
Loadable Dumbbells		16	2000(bar length) +2000mm (safety space) * 2000mm (safety space)	12,000mm²
Bench		8	2000(length)+1000mm (safety space) * 2000mm(width)+1000mm (safety space)	90,000mm²
Pulley System		8	2000(bar length) +2000mm (safety space) * 3000mm (safety space)	96,000mm²
Aerobic Area				
Warmup Area				
Assault Bike		8	2200mm² (total space) + 500mm (additional safety space)	21600mm²

3.0 SUMMMARY, CONCLUSION AND RECOMMENDATIONS

In conclusion, the training program in this study provided an insight on implementing velocity profiling into an Olympic weightlifting training program. The device in this study (PUSH Band) quantifies the bar movement via the force velocity curve and the coach has a clearer means in which to determine the repetitions that follow. For this reason, the exact sets and repetitions per each phase have been left to the coaches' discretion in conjunction with the additional factors given from the accelerometry device, allowing the program to have a dynamic means in which to prescribe loading within the prescribed FVP per phase and further individualization of the program. This study is based around the theoretical idea of implementing a means in which to avoid the traditional periodization rep schema to administer training volume, but rather utilize new technologies. The force velocity profile may provide a greater view of the athlete's performance status through quantifying the movement of the bar and potential fibre type utilization, in addition to ensuring that the athlete maintains optimal loading to maximize the benefits of each phase. Apart from the 1RM prescription of loading, Suchomel *et al* (2017) described a novel approach to prescribing volume to athletic training programs using the FVP which runs concurrently to the goals set forth in an Olympic weightlifting program.

To conclude, methods that accommodate for velocity profiles to determine volume in conjunction with 1RM percentages and a coach's discretion may allow for more efficient training and a reduction in excess fatigue. In addition, the necessity arises to maintain a sport specific demand in terms of volume and intensity when coming to weightlifting where an athlete may be able to complete the lift in training but not meet the demands. Using new technologies to understand the athlete at every stage of development, we can begin to avoid the clutter of unnecessary loading to have the athlete work on what needs to be done in a more efficient manner.

Limitations

- The main limitation of this program predominantly resides in the quantification of the force and acceleration of the movement in an efficient manner, the implementation of accelerometry may be deemed clunky or intrusive to the athlete when completing Olympic lifting.
- Without having a predictive means to gauge the athlete's 1RM before the program takes place, the coach must either calculate a prediction on their 1RM or plan a separate testing day.
- Equipment might not be available at time of training program implementation.
- A team of 32 athletes could have problems when sharing platforms or equipment.
- The lack of a medical professional on-site may negatively impact sick days or leaves.
- There is no means in which to quantify potential symptoms of sickness other than the RPE scale and Athlete Diary.
- Athlete may have issues when expressing or filling out Athlete diary truthfully.
- Program does not accommodate for potential computer issues that may occur during training; however, a cloud-based logging system may solve this issue.
- A weekly 3RM or 1RM may be too fatiguing for athletes and leaving it to the coach's discretion might not be the best option for an inexperienced coach.
- Leaving assistance movements or variations may not be the best option for an inexperienced coach.

APPENDIX

Testing Protocols

Physical Activity Readiness Questionnaire (PAR-Q):

National Academy of Sports Medicine (NASM) Guidelines:

- Has your doctor ever said that you have a heart conditioning and that you should only perform physical activity recommended by a doctor? Y/N
- Do you feel pain in your chest when you perform physical activity? Y/N
- In the past month, have you had chest pain when you were not performing any physical activity? Y/N
- Do you lose your balance because of dizziness or do you ever lose consciousness? Y/N
- Do you have a bone or joint problem that could be made worse by a change in your physical activity? Y/N
- Is your doctor currently prescribing any medication for your blood pressure or for a heart condition? Y/N
- Do you know of any other reason why you should not engage in physical activity? Y/N

If you have any YES to any of the above questions, consult your physician before engaging in physical activity. A signed physician release form will be required to participate in the team training program.

Additional Questions:

- Do you have a previous training record? Y/N (If Yes, please provide training record to current coach)
- What is your best Snatch in competition? (_kg)
- What is your best Clean and Jerk in competition? (_kg)
- What is your best Snatch in training? (_kg)
- What is your best Clean and Jerk in training? (_kg)
- What is your best Clean in training? (_kg)
- What is your best Jerk in training? (_kg)

Table 12: Goniometric Measurements

No.#	Area of Body	Movement	Range of Motion Score (°)
1	Back	Extension	_/25°
		Flexion	_/90°
2	Lateral Flexion	Left	_/25°
		Right	_/25°
3	Neck	Extension	_/60°
		Flexion	_/50°
4	Neck (Lateral)	Left	_/45°
		Right	_/45°
5	Neck (Rotation)	Left	_/80°
		Right	_/80°
6	Hip (Backward Extension)	Left	_/30°
		Right	_/30°
7	Hip (Flexion)	Left (Knee Flexed)	_/100°
		Left (Knee Extended)	_/100°
		Right (Knee Flexed)	_/100°
		Right (Knee Extended)	_/100°
8	Hip (Adduction)	Left	_/20°
		Right	_/20°
9	Hip (Abduction)	Left	_/40°
		Right	_/40°
10	Knee (Flexion)	Left	_/150°
		Right	_/150°

Table 13: Rate of Perceived Exertion (RPE) Survey:

Difficulty Rating	Perceived Exertion
1	No challenge
2	Very Easy
3	Easy
4	Moderate
5	Fairly Hard
6	Hard
7	Maximum Effort

Athlete Diary

- Are you experiencing any illness or flu-like symptoms? Y/N
- If so, what are your symptoms?
- How are feeling today from 1-5? (1 (Very Poor) – 5 (Very Good))
- How is your focus today from 1-5?
- How stressed are you today from 1-5?
- On average, how many hours of sleep have you had per night in the last 24-48 hours?
- What would you rate the quality of your sleep from 1-5?
- Have you consumed alcohol in the past 24-48 hours?

- If so, how many drinks did you have roughly?
- Have you consumed any illegal substances in the past 24-48 hours?
- If so, what, and how much did you consume roughly

Additional Comments

Training Modalities

Table 14: Sport Specific Movements

Movement	Technique	Variation
Snatch		
	Full Snatch	
		Pull Blocks
		3 Position
		Hang (Knee or Hip)
	Power Snatch	
		Pull Blocks
		3 Position
		Hang (Knee or Hip)
	Snatch Pull	
		Pull Blocks
		3 Position
		Hang (Knee or Hip)
	Muscle Snatch	
		Pull Blocks
		3 Position
		Hang (Knee or Hip)

Table 14: Sport Specific Movements

	Drop Snatch	
		From Rack
Clean and Jerk		
	Full clean	
		Pull Blocks
		3 Position
		Hang (Below or Above Knee)
	Power clean	
		Pull Blocks
		3 Position
		Hang (Below or Above Knee)
	Split jerk	
		From Rack
		From Blocks
		Jerk Drive
	Power jack	
		From Rack
		From Blocks
	Squat jerk	
		From Rack
		From Blocks
		Jerk Drive

Table 15: Strength Movements

Movement	Technique	Variation
Squat		
	Back Squat	
		Tempo
		Paused
		Bottom-Up from Rack
	Front Squat	
		Tempo
		Paused
		Bottom-Up from Rack
	Overhead Squat	
		Tempo
		Paused
		Bottom-Up from Rack
	Split Squat	
		Tempo
		Paused
		Front Rack
		Dumbbell
Press	Overhead Press	
		Tempo
		Dumbbell
	Push Press	
		Paused
	Bench Press	
		Tempo
		Paused
		Bottom-Up
Row		
	Bent	
		Tempo
		Paused
		Bottom-Up
Deadlift	Clean grip	
		3-Position
		Tempo
		From Blocks
		Deficit
	Snatch grip	
		3-Position
		Tempo
		From Blocks
		Deficit
	Romanian	
		Tempo
		From Blocks
		Deficit

Table 15: Strength Movements

Table 16: Assistance Exercises

Push	Tricep	
		Cable pushdown or overhead Dumbell kickback or overhead
	Quadricep	
		Seated on machine Dumbell lunge
	Back	
		GHD Good morning (Seated or standing)
Pull	Latissimus	
		Pull down (Wide, narrow or neutral) Pull up (Wide, narrow or neutral) Dumbell row Cable row
	Scapula	
		Hanging retraction Cable retraction Banded pull apart
Torso	Stability	
		Bird dog Dead bug Hanging leg raises Glute bridge

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