A COMPARISON OF CONDITIONING LEVELS BETWEEN OFF-SEASON AND COMPETITION SEASON FOR DIVISION II WOMEN'S VOLLEYBALL

Amy J. Molenaar
Northern Michigan University

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A COMPARISON OF CONDITIONING LEVELS BETWEEN OFF-SEASON AND COMPETITION SEASON FOR DIVISION II WOMEN’S VOLLEYBALL

By

Amy J. Molenaar

THESIS

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In partial fulfillment of the requirements
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This thesis by Amy Jo Molenaar is recommended for approval by the student’s thesis committee in the Department of Health, Physical Education, and Recreation and by the Dean of Graduate Studies.

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August 9, 1977
ABSTRACT

A COMPARISON OF CONDITIONING LEVELS BETWEEN OFF-SEASON AND COMPETITION SEASON FOR DIVISION II WOMEN’S VOLLEYBALL

By

Amy J. Molenaar

The purpose of this study was to compare conditioning levels between off-season and competition season training cycles during a women’s collegiate volleyball annual training cycle. For this study 10 Division II collegiate female volleyball players adhered to two separate 13 week periodized strength and conditioning programs. The off-season program consisted of 13 weeks starting in May and ending the beginning of August. The competition season program started the beginning of August and concluded the beginning of November. The frequency for off-season training was 4 times per week which decreased to 3 times per week during the competition season. A battery of field tests was administered to measure muscular strength and endurance, power, agility, and anaerobic capacity. The field tests utilized were the vertical jump test, 1 minute sit-up, T-Test, 300 yard shuttle run, and 1 repetition maximum back squat. Measurements were taken on three separate occasions which included baseline, pre-season, and post-season. The findings of the present study indicate that off-season strength and conditioning levels for anaerobic capacity, muscular strength and endurance can be maintained during the competition season when the frequency of training is decreased to three days per week. Therefore, athletes that wish to maintain and in some areas increase conditioning levels, may decrease the frequency to three days per week during the competition season.

KEYWORDS: Periodization, Field Tests, Athlete Profile, Resistance Training, Frequency
DEDICATION

I would like to dedicate this thesis to my parents for their generous love and support during a chosen season of my life you did not always understand. Your patience, effort in trying to understand academic life and willingness to counsel and listen overwhelms me. Thank you for encouraging me to view the peaks and valleys this journey affords in light of eternity. Your steadfastness and consistency helps to keep me grounded. With the utmost sincerity and gratitude, I thank you.
ACKNOWLEDGMENTS

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An additional thank you and credit is given to Dr. Phil Watts for also being a member of my thesis committee. Thank you for putting thought into salvaging my research project when I thought all was lost. Thank you for your critical thought and answering many questions about research and presenting of research subtly through classroom lectures.

I would also like to thank Dillon Carr for the numerous hours spent mentoring, guiding, reading, re-wording, and problem solving. Your willingness to step in when I needed a research assistant during my data collection was only an act a dear friend would do. Thank you for sharing in the excitement for university lifestyle, learning, and critical thinking. Even though I claim to thrive under pressure, you were the calming effect when the waters of that pressure wanted to take me under; not to mention pull my hair out...
(literally). You were divinely the perfect person to help me see the sun behind the clouds of a tiring, busy academic year. I don’t know what I would have done without you by my side.

I would like also like to recognize and thank my colleagues and the volleyball team at Lake Superior State University, your collaborative dedication to the success of my thesis is insurmountable. I want specifically thank Mark Engle for his willingness to use his volleyball team as subjects. I also recognize that I wouldn’t be where I am today without you giving me a chance as a player which afforded me the opportunity to continue on to graduate school. Thank you!

Also at Lake Superior State University, I would like to recognize Jody Susi for being a member of my committee, friend, and an encouragement to me through the busy semesters of graduate school. Your dedication in pursuing your dreams inspires me! Lastly, I would like to thank and acknowledge Andy DeShambo, for his communication and implementation of the competition season strength training and conditioning program.

I would also like to thank the staff at Cal’s Party Store particularly Ted, for keeping their shelves stocked with fresh baked goods and cold Diet Mountain Dew.

This thesis follows the format prescribed by *Journal of Strength and Conditioning Research* as recommended by the Department of Health, Physical Education, and Recreation.
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CHAPTER I
MANUSCRIPT SUBMISSION:
Journal of Strength and Conditioning Research

INTRODUCTION

Proper strength training and conditioning are one of the primary methods that have proven successful in injury prevention and improvement in sports performance (31,39). However, time restrictions placed on competitive intercollegiate athletes by the National Collegiate Athletic Association (NCAA) for both off-season and competition season make it difficult for coaches to implement, mandate and control strength training and conditioning programs. During the competition season a maximum of 20 hours per week is allotted for team practices, strength training, conditioning and team meetings. This restriction during the competition season makes it difficult for coaches to emphasize resistance training when the focus is on skill and technical training. Minimizing the frequency required for physical conditioning may reduce training time yet allow athletes to maintain conditioning levels throughout a competition season. Further, the effectiveness of decreased frequency remains unclear in women’s collegiate athletics, particularly for women’s volleyball (40).

Due to time constraints and a shift in focus from physical conditioning to skill and technical training during the competition season, coaches may use a subjective approach to determining the appropriate frequency for physical conditioning. In order to maintain off-season strength training and conditioning levels a minimum of two days per week is often recommended during the competition season (70). However, recommendations for competition season conditioning need not be restrictive. A range of training parameters
are possible that will maintain conditioning (70). Players may train between one and three times per week throughout the competition season and produce positive results (28). Decreasing strength training and conditioning frequency requires coaches to plan the proper frequency, intensity, and type of conditioning to maintain off-season conditioning levels during the competition season (11). Consequently, a decrease in frequency without proper planning can be detrimental to the conditioning levels obtained from an off-season program.

Incorporating an annual periodization training cycle can guide strength training and conditioning personnel in the creation and implementation of team sport training. The main objective yet most difficult part of designing an annual training plan is to program athletes to peak their conditioning level and reach a high level of performance for a pre-determined time (12). For collegiate volleyball players, their goals are to peak performance at the end of the season for championship play and attain high performance levels at the end of each week for matches. To achieve such a performance, coaches must properly periodize and plan the entire annual training plan so the development of skills, biomotor abilities, and psychological traits follow a logical and sequential order of training and rest (12).

In order to maintain physical conditioning levels obtained from off-season conditioning programs, periodization of strength training and conditioning is characterized by high initial volume and moderate intensity training during the off-season phase. The transition from off-season phase to the competition phase, intensity progressively increases while volume inversely decreases until a peak is reached at the end of the competition phase (62,66,71). In addition, tactical and technical training also
typically increases as the weight training volume decreases. The inverse relationship is created to maximize strength gains, minimize boredom, reduce injuries, and minimize overtraining (15,34,47,62,71).

It has been shown that a low volume, high intensity competition season conditioning program may not be sufficient to maintain lean body mass in power sports athletes, specifically male football players during pre-season (28). Baker (6) found that an acute decrease in strength and high-speed force occurred when resistance training was preceded by a regimen of 25 minutes of mixed, high-intensity aerobic and anaerobic conditioning in football players during their competition season. These findings suggest that similar decreases could be found during the competition phase for volleyball where resistance training and large amounts of team practice must be performed during the competition season.

A number of studies have investigated whether strength could be maintained across competition seasons in football, despite the increase in game, practice, and conditioning demands (6). Fleck and Kraemer (21) and Baker (5) reported that measures of strength can be maintained 14-16 weeks into the competition season in collegiate football. However, Schneider et al. (63) reported significant losses in strength 13-14 weeks into the competition football season. For all of the previous studies, it was presumed that combined demands of practice and competition and frequency of training and rest were a detrimental factor in conditioning levels (6).

To date, few studies have examined the effects of a decrease in frequency of strength training and conditioning and the demands of competition season stresses during the competition season for female collegiate volleyball players. To date, the majority of
studies examining periodization of strength training and conditioning have used a traditional strength and power model of decreasing training volume and increasing training intensity as the program progresses. However, most of the literature available has used males as subjects (18). Despite this, an increase in strength and lean body mass, a decrease in percentage body fat, and improved functional abilities have been shown to be equally attainable for men and women through use of similar strength training methods (21). This suggests that similar results should be found for the same strength training and conditioning studies for women, yet this relationship remains unclear.

Strength training and conditioning programs for volleyball are designed to create movements in the weight room that build strength and speed that are not only necessary but are easily translated onto the court (53). Volleyball is an explosive, fast-paced sport and during a match, players must be physically prepared for continuous jumps, changes of direction, and repeated attacking of the ball (33). Furthermore, high levels of muscular endurance are also important to permit these actions over a long period of time (20). Volleyball athletes must develop the power to apply their skills, plus muscular endurance to continue high levels of application throughout the entire game and match. Consequently, a goal of volleyball practice and conditioning is to provide a stimulus for volleyball-specific adaptations that will result in improved athletic performance.

To achieve an elevated level of performance volleyball requires a high degree of muscular strength and power. Although strength and power may be easily developed during the off-season training phase, there is some question as to whether pre-season levels of strength and power can be maintained during a long-competition season with a
decrease in frequency of training sessions. This is especially true when a large amount of conditioning, lengthy team practices and travel are performed in succession (6).

Few longitudinal studies have evaluated the potential advantage of using a periodized resistance training program in women collegiate volleyball players. Therefore the purpose of this investigation was to compare conditioning levels between two phases of a periodized annual training cycle. The intent was to determine if off-season conditioning levels can be maintained during the competition season with a decrease in the frequency of strength training and conditioning sessions from four to three.

Assessments of anaerobic capacity, power, agility, muscular strength and endurance were used to determine the effectiveness of the off-season and competition season programs and to present a comprehensive view of such training in Division II, women volleyball players. Measurements of the training gains were based on the changes in the subjects’ vertical jump height, 1 minute sit-up test, T-Test, 300 yard shuttle run, and 1 repetition maximum 1 repetition maximum (1RM) back squat.

METHODS

Approach to the Problem

The current study evaluated the decrease in frequency of strength training and conditioning in women’s collegiate volleyball players from four times per week during off-season training to three times per week during the competition season. The purpose of the investigation was to compare conditioning levels across off-season and competition season training cycles during women’s collegiate volleyball seasons.

A battery of pre and post tests was administered to gather baseline and training differences. These tests consisted of the vertical jump height, 60 second sit-up test, T-
Test, 300 yard shuttle run, and 1RM back squat. Results from these tests measured the subject’s anaerobic capacity, agility power, and muscular strength and endurance.

**Subjects**

Ten women volunteered to participate in the study. Subjects were all members of the Lake Superior State University, women’s, Division II volleyball team and were 18-23 years of age. Each of the subjects was familiar with and engaged in the resistance training exercises and tests required for this study during the previous competition season prior to testing. None of the individuals reported any medical or orthopedic problems that would compromise participation in the study. The study was approved by the Northern Michigan University Human Subject Review Committee (HS08-172) and informed consent documents were signed by all subjects prior to the beginning of testing procedures.

**Procedures**

For inclusion in this study subjects were required to complete 80% of the off-season workout to be included in the analysis. Compliance of the program was analyzed by requiring subjects to keep track of their off-season conditioning in a journal provided by the researcher. The 27 week study had two separate training periods: the training periods were named off-season (OS) and competition season (CS). During the OS the frequency of strength training and conditioning training was four times per week and there was no required skill or technical training. During the CS the frequency of strength training and conditioning was three times per week and competition and skill training was five times per week.
Training Periods

The OS training period was 13 weeks in duration, periodized and broken down by conditioning focus. The OS training consisted of two, six week cycles involving two weeks of hypertrophy, strength, and power. Following each six week cycle was a taper week of lower total work-out volume (Appendix B).

Each week was further broken down into four training days consisting of two non-consecutive lower body and two upper body resistance training days. In addition to lower body resistance training subjects chose two ground based plyometrics and two agility activities provided by the researcher. On their upper body resistance training days, subjects also engaged in an aerobic conditioning activity for 20-30 minutes at 75% of their maximal heart rate. They were allowed to select the exercise from a stair climber, treadmill, and bicycle. Age predicted maximal heart rate was determined by 220 - age. In addition on all of the training days a required flexibility program and a list of four core exercises were provided by the researcher. The list of core exercises included bicycle kicks, leg extended V-ups, crunches, cherry pickers with a pound medicine ball. The OS training cycle was periodized using weight training intensities ranging from 65–95% of pre-existing 1RM (4).

The CS training period was a non-periodized 13 week program that was broken down by days of the week. Each day of the week consisted of a combination of conditioning, team practice, and competition. A variant of circuit training was on Monday, resistance training on Tuesday, plyometrics on Wednesday, and competition on Friday and Saturday. In addition to the physical training, a two hour team practice was held on Monday, Tuesday, Wednesday, and Thursday. The main objective of daily
practice was to develop technical volleyball related skills through continuous, multiple high-intensity drills that mimic movements and situations by position of match play. This goal was obtained by including physical demands that could be placed in two modes of exercises such as jumping and footwork. The number of jumps during practice is considerably higher than in a match (9,54).

The variation of circuit training consisted of four resistance training stations set up around a 200 meter track in a multi-purpose room. Circuit training sessions consisted of a combination of four machine lifts for endurance and speed, 100 meter sprints at 75 to 90% maximum, and push-ups. The bicep curl, triceps extension, chest press, and leg press machines were used for 10 seconds. A typical circuit was as follows. The subjects used a weight machine for 10 seconds, completing as many repetitions as possible, then subjects ran 100 meters where they would do 10 push-ups, sprint for another 100 meters, do 10 pushups, and then rest for two minutes. This circuit would continue until the subjects completed all four of the weight machines two times.

The resistance training consisted of a 45-60 minute program. Generally the lifts consisted of three sets of 10 repetitions using one exercise for chest, back, triceps, biceps, shoulder, gastrocnemius, hamstrings, and quadriceps.

The plyometric training consisted of a five station plyometric circuit lasting 30 to 40 minutes. The five stations were a combination of the following: lateral band jumps for height and speed, left and right lateral one step shuffles with a band around their quadriceps, depth jumps, box jumps of various heights, t–test, frog jumps, and a core exercise of choice.
Physical Testing

Data were collected on three separate occasions from the same battery of tests and testing day protocol. The battery of tests was taken from a recommended list designed and approved by the National Strength and Conditioning Association (NSCA) (4). Baseline data was collected prior to the start of the 13 week OS on April 26, 2008 (May 5 to July 31). The second data set was collected a day before the start of CS on August 12, 2008 (August 13 to November 7). The post season data were collected following the completion of a 13 week competition season on November 9, 2008.

All three of the testing times followed the same protocol. The subjects started with a three minute sub-maximal jog and dynamic warm-up. The warm-up utilized was identical to the warm-up incorporated in the OS work-out and consisted of continuous dynamic movements of 13 exercises which were performed 60 meters each. The warm-up utilized dynamic exercises including rotational movements of the hip flexors, forward and side lunges, a running zig-zag, high knees lifts, butt kicks, carioca with a high knee cross over, skip and reach, side shuffle, and directional hops (Table 1).

Immediately following the dynamic warm-up, the testing battery began with the vertical jump. The vertical jump height was measured by using a tape measure on the wall. The subject began by standing with their right shoulder approximately 15 cm from the wall and with both feet flat on the floor. The subject then reached as high as possible with their right hand. Their standing reach was recorded by the researcher. The subject then lowered their right hand and, without a preparatory or stutter step and jumped. At the highest point in the jump, the subject reached up with their right hand and tapped the
highest point on the tape measure possible. The score was the vertical distance between the height of the standing reach and the highest point of the jump.

To measure the subjects’ agility two trials of a T-Test were administered with the fastest of the two scores recorded for each individual. The T-Test is a standard measure of agility requiring subjects to move through a T shaped pattern in as little time as possible (4). Cones are placed at each of the three ends and at the intersection to form the T. Subjects began the test at the base of the T, cone A, and sprinted forward 10 yards to touch cone B located at the intersection of the T. After touching cone B subjects then shuffled to their left five yards to touch cone C, located on the left end of the T. Subjects then shuffled to their right 10 yards to touch cone D, located on the right end of the T, before shuffling back to their left to touch cone B at the intersection. Finally, subjects sprinted backwards from cone B to cone A to stop the timer and complete the trial.

To determine muscular endurance a one minute sit-up protocol was used. Subjects were randomly split into pairs for which one could take the test while the partner held the feet and counted the number of sit-ups performed properly. Proper form was met if subjects raised their upper body to the up position with their elbows touching their thighs and then lowered their body until the upper portion of their back touched the mat. The head, hands, arms, and elbows were not required to touch the ground (4).

The 1 repetition maximum (RM) back squat was administered to determine the subject’s 1 RM. Four back squat stations were set up to include three warm-up and one final testing station. In sequential order the subject started the warm-up at station one, lifting 5-10 repetitions of a light resistance. After a one minute rest the subject went to the next station where they performed 3-5 repetitions after adding an estimated 10-20%
(14-18 kg) of their estimated 1 RM load. After a two minute rest, the subject performed 2-3 repetitions of an additional 10-20% (14-18 kg) weight. After a two to four minute rest, the subject was instructed to make their final load increase, an additional 10-20% (14-18 kg) and execute their 1 RM lift. If the estimated load for the final test was too heavy or too light, the final test failed and the subject was given a two to four minute rest period and the load was decreased or increased by 5-10% (7-9 kg) and the final test was repeated (4).

The 300 Yard Shuttle Run was used to determine the subjects’ anaerobic capacity. One trial was administered and the score was the time calculated to the nearest 0.1 second. Subjects were paired off having one subject run while the other counted touches for the partner. On the testers’ signal, the subjects sprinted to a marked 25 yard line and returned to the starting line for a total of six round trips totalling 300 yards. Foot contact was required to be on the starting line and the 25 yard line when changing directions (4).

**Statistical Analysis**

A repeated measures analysis of variance (ANOVA) was conducted to compare the test scores within the subjects and testing periods. Data were gathered three separate times for the two testing periods. The testing periods were baseline to pre-season and pre-season to post-season. An alpha level of 0.05 was used to determine significance for all comparisons. In the case of significance, follow-up comparisons were made using the Bonferroni adjustment. Statistical analysis was completed using SPSS version 16.0 (SPSS Inc., Chicago, IL).
RESULTS

A total of ten subjects completed at least 90% of the summer work-outs, 100% of the competition season work-outs, and were included in the analysis. Each individual was tested three separate times to measure the effect on conditioning resulting from two phases of a periodized training cycle. Baseline, pre-season, and post-season testing each examined subjects across the five standard measures of physical conditioning discussed above. The lone exception is one individual who did not participate in the baseline shuttle run test and that individual is excluded here from the analysis of that specific test.

The repeated measures ANOVA indicated significant within-subjects variance when the three testing periods were compared for the vertical jump test. Pairwise post hoc comparisons indicated a significant increase in vertical jump height for the baseline to pre-season (p = 0.002), while vertical jump scores between the pre-season and post-season testing periods were not different (p > .05) (Table 2) (Figure 1).

The repeated measures ANOVA indicated significant within-subjects variance when the three testing periods were compared for the sit-up test. Over the three testing periods for the sit-up score, results from the pairwise post hoc comparisons indicated a significant increase between the baseline and pre-season (p = 0.004) and between the baseline and post-season testing (p = .015), while sit-up scores between the pre-season and post-season testing periods stayed the same (Table 2) (Figure 2).

The repeated measures ANOVA indicated significant within-subjects variance when the three testing periods were compared for the 1 RM back squat. Pairwise post hoc comparison for the 1 RM back squat indicate a significant increase in score over the three testing periods. The increase was found between baseline and pre-season (p = 0.025), pre-
season and post-season testing (p = .017), and between baseline and post-season testing (p = .008) (Table 2) (Figure 3).

The repeated measures ANOVA indicated significant within-subjects variance when the three testing periods were compared for the T-Test. Results between the three testing periods indicated a significant change in the time ran. The pairwise post hoc comparison indicated a significant decrease in time ran between the baseline and pre-season (p = 0.003) and a significant increase in time ran between the pre-season and post-season (p = .015). The scores between the baseline and post-season testing stayed the same (Table 2) (Figure 4). Results from the repeated measures ANOVA comparisons indicate there was no significant change between the two testing periods for the 300 yard shuttle run (Table 2) (Figure 5).
Table 1. Dynamic Warm Up.

Activities are done consecutively in a continuous 60 meters loop with no rest in between.

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Activate Hip Flexor – Forward</td>
</tr>
<tr>
<td>2.</td>
<td>Activate Hip Flexor – Reverse</td>
</tr>
<tr>
<td>3.</td>
<td>Forward Lunge</td>
</tr>
<tr>
<td>4.</td>
<td>Side Lunge w/ reverse pivot</td>
</tr>
<tr>
<td>5.</td>
<td>Zig-zag Run</td>
</tr>
<tr>
<td>6.</td>
<td>High Knees</td>
</tr>
<tr>
<td>7.</td>
<td>Butt Kick</td>
</tr>
<tr>
<td>8.</td>
<td>Carioca w/ high knee cross over</td>
</tr>
<tr>
<td>9.</td>
<td>Skip and Reach Forward and Backward</td>
</tr>
<tr>
<td>10.</td>
<td>Skip Forward – Swing Arm Forward</td>
</tr>
<tr>
<td>11.</td>
<td>Skip Backward – Swing Arm Backward</td>
</tr>
<tr>
<td>12.</td>
<td>Skip with Lateral Knee Lift and Twist</td>
</tr>
<tr>
<td>13.</td>
<td>Side Shuffle</td>
</tr>
</tbody>
</table>
Table 2. Inter-season comparison of strength and conditioning levels.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Pre-season</th>
<th>Post-season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 RM Back Squat (kg)</td>
<td>117.27 ± 26.53</td>
<td>125.46 ± 12.58†</td>
<td>133.18 ± 8.98†</td>
</tr>
<tr>
<td>Vertical Jump (cm)</td>
<td>46.86 ± 4.17</td>
<td>50.80 ± 3.69†</td>
<td>49.91 ± 4.83</td>
</tr>
<tr>
<td>Sit-ups (per 60 s)</td>
<td>48.50 ± 7.46</td>
<td>53.00 ± 6.22†</td>
<td>53.00 ± 5.83</td>
</tr>
<tr>
<td>T-Test (s)</td>
<td>10.64 ± .35</td>
<td>10.19 ± .33†</td>
<td>10.49 ± .23†</td>
</tr>
<tr>
<td>300 yard Shuttle Run (s)</td>
<td>66.56 ± 2.24</td>
<td>65.78 ± 1.92</td>
<td>66.56 ± 1.33</td>
</tr>
</tbody>
</table>

*Values are mean ± SD
†Change from previous testing period is significant P < .05
Figure 1: Change in mean Vertical Jump scores between testing periods.
Figure 2: Change in mean Sit-Up scores between testing periods.
Figure 3: Change in mean 1RM Back Squat scores between testing periods.
Figure 4: Change in mean T-Test scores between testing periods.
Figure 5: Change in mean 300 yard Shuttle Run scores between testing periods.
DISCUSSION

The results of the current study indicate that gains made in anaerobic capacity, muscular power, strength and endurance from off-season strength training and conditioning program were maintained during the competition season. However, measures of agility decreased throughout the competition season. It appears that during the competition season a particular balance, volume, and combination of physical conditioning and sport specific drills during team practice may be vital for the maintenance of the physical conditioning levels of volleyball players.

The ultimate goal of volleyball practice and physical conditioning during the competition season is to provide a training stimulus that results in volleyball specific adaptations that improve athletic performance for a specific point in time (12). Findings from the current study may significantly affect program design and long-term prescription of resistance training programs for women volleyball players.

In most team sports practices coaches recreate situations by position that put their players in similar match movements and physiological demands specific to competition (50). As a whole volleyball players are required to position their body in an athletic posture with the knees bent and weight forward. Attackers engage in multiple, repetitive drills that incorporate jumping mechanics and quick, dynamic movements (34). Continued movements such as these may elicit a threshold of an overload that produces an increase in muscular strength, endurance, and power while incorporating their anaerobic energy system. Even though there is a decrease in the frequency of strength training and conditioning, the current study illustrates that with the proper combinations
of intensity in both practice and in the weight room, conditioning levels from off-season can be maintained.

A high level of physical performance in sports requires the application of sport specificity in practice and physical training (33). Physical training for maximum rate of force development should imitate game movements in pattern, velocity, contraction type and force, in a manner that is similar to the movements that make up the sport of volleyball (11).

For the current study, movements and resistance training in the weight room for off-season conditioning were highly similar to actual movements of the game and were based on training movements not muscle groups which allow for a better carry-over onto the court (11,32). The current study’s findings are consistent with those reported by Newton et al. (56) who compared Division I male volleyball players who used ballistic movements and resistance training during their competition season. The outcome lends support to the effectiveness of the combination of resistance training and daily practice for improving muscular strength and power in elite jump athletes during the competition season.

In addition, strength training and conditioning movements should provide an adequate overload to effect positive adaptations (33,50). The body will attempt to minimize the overload or stress from conditioning by adapting to it. If the frequency or volume of physical conditioning is too great with not enough of an overload, the training will not provide enough of a stimulus to increase the physical condition (4,32). This suggests that decreasing the volume of strength training and conditioning is necessary in order for athletes to allow the proper stimulus of training to occur.
Although practical and observational evidence suggests that there is a relationship between weightlifting movements and their ability improve athletic performance, limited studies have evaluated this relationship for female sports (29). In addition, movements such as sprinting, stopping, changing direction and throwing are movements that all increase due to physical training and aid in volleyball performance, yet are difficult to measure. This suggests that additional research is needed for periodized agility and sprinting programs.

Further, despite the fact that weightlifting movements require more time for learning than do resistance exercises using machine, they seem to be more beneficial for improving performance (29). The greater skill complexity required for the weightlifting exercises and using a modality that is similar to the sport facilitates the development of a broader physical abilities spectrum, which seems to be better transferred to performance (50). Again, the effects of weightlifting on performance are unclear, especially in women and suggest a need for further research.

Combining the effects of strenuous physical activity resulting from practice, conditioning, and competition may adversely affect physical conditioning levels due to lack of rest (5). For instance, important to the rate of force development is the manner in which muscles recover following exercise stressors such as practice, conditioning, or competition (33,41). Combination of both training and competing creates a dynamic homeostatic balance between anabolic and catabolic processes within the muscle. If the physical demands of practice, conditioning, and competition are too great, it might be hypothesized that catabolic activities will predominate (22). However, if the body is able to successfully manage the demands, anabolic metabolism can help to maintain or
improve performance over the course of the season (25). This imbalance could greatly affect speed and muscular strength and endurance.

For the current study, overtraining may be one of the explanations for the decrease in agility. The present variability between athletes and their ability to recover from the combination of competition and practice may have influenced their performance. In addition this variability may interfere with the development of agility because of the time devoted to improving the other physical conditioning components and the interference effects particularly of the training for foot speed (38).

It may also result in an acute overtraining phenomenon prior to or during pre-season which elevate certain hormone levels. Kraemer et al. (41) reported that soccer players that have elevated levels of testosterone and cortisol can experience reductions in performance during a season, with performance decrements worse in starters compared to non-starters. The adverse effects of inappropriate training over a year, especially during the off-season and expecting to in the pre-season do not appear to be unloaded during the season and catabolic activities can dominate.

Although periodization has become a household word in recent years among athletes and coaches the actual supporting evidence for it is limited (15,34). A review by Fleck (18) covering eight different periodization studies points out that while the athletic community has been using periodization for at least 40 years, few published projects have investigated the efficacy of periodized strength training. Fry et al. (25) noted that while periodization is widely used for designing training programs, which has led to a significant number of articles on the topic, most of the information contained in the literature is speculative and not supported by research (15).
Most of the information concerning periodization is the result of observational evidence, anecdotal data, inference from other periodization related studies, and short-term periodized studies (15,66). Additionally, there is a lack of research supporting its use and its effects during a competition season. The results of the present study support previous findings of periodization within collegiate conditioning programs using males, which suggests a similar finding is plausible for women.

Most of the previous studies involving periodization are short in duration due to the researchers being in university settings, which conveniently allows the duration of a research project to be linked to an academic semester (15). The use of a university setting can limit the availability and willingness of athletes for subjects. Coaches and athletes are generally understandably hesitant to change their training program and therefore volunteer as a subject. This resistance makes recruiting athletes as subjects and utilizing more than one academic semester for research difficult (15). This limitation makes it difficult to apply results observed in non-athletes to athletes and short-term studies with long-term studies and could affect the overall annual training cycle (15). Studies examining periodized models other than the traditional strength and power periodized model are needed as well. Further, very little data exists concerning long-term resistance training adaptations in women (65).

In order to expand the scope of periodization research beyond an academic semester, a 13 week strength training and conditioning program was utilized during the off-season. However, the majority of the testing measures resulted in significant positive outcomes creating a high level of validity regarding the compliance with the off-season training program. Competition season physical conditioning compliance was controlled
for by being a required part of daily practice, which was monitored by the collegiate strength training and conditioning coach.

The current study illustrated that implementation of periodization does work and can be used by strength and conditioning professionals. It is clear that limited data exist on female collegiate volleyball players and for physical skills other than weight training. The lack of literature and research available is problematic because athletes train to improve speed, agility, flexibility, and sport-specific skills in addition to strength training (15). Increasing periodization research in this area and for women would give coaches, athletes and researchers norms and baseline measures which to compare physiological measures to. This could create an opportunity for additional research involving periodization to measure gains of sport specific skill and possibly performance gains.

**PRACTICAL APPLICATION**

The creation and implementation of a sport specific and annually periodized strength training and conditioning program is essential for maximizing and maintaining conditioning levels. The findings of the present study indicate that it is possible to maintain measures of anaerobic capacity, muscular power, strength, and endurance from off-season conditioning levels during the competition season without spending as much time conditioning as in off-season.

In order to peak the performance of a team sport, proper microcycle and macrocycle training must be incorporated with the entire competition season in mind. The goal of the competition season is to find a balance between and prioritize strength training and conditioning, practice, rest, and competition on a weekly scale allowing for a good end of the season record. Incorporating a properly scheduled practice and strength
in conditioning also helps ensure that overtraining is not an issue and helps to increase the chance of post-competition season championship tournament contributions. Incorporating a decrease in strength training and conditioning frequency during a competition season can be implemented if planned appropriately to maximize the post-competition season tournament play.

A limitation of this study was the difficulty in defining specific volume for either program except by using the training duration. Volume and intensity are seldom quantified in team sports, leaving one to wonder how coaches monitor their athletes’ training especially when using periodization.

Previous literature is relatively short term in nature especially if the results are placed in the context of an athletic career or a lifetime of recreational fitness training. Therefore, a future direction of research concerning periodized strength training should be longer term studies and with the use of females. Future studies are also needed concerning all outcomes of periodized training compared to non-periodized training, but especially concerning body composition and being able to measure performance changes.

A long term goal of research concerning periodized training should be to understand why periodized training may result in greater fitness and or performance gains. If this is understood, it will be substantially easier to design optimal strength training programs to meet the goals and needs of elite athletes and the physical fitness for the general population.
CHAPTER II
REVIEW OF LITERATURE

INTRODUCTION
With the growing concern for strength training and conditioning training in collegiate settings, it’s hardly surprising that the relationship between strength training and conditioning and performance among collegiate athletes has attracted considerable amount of current attention. In an attempt to find the best combinations for top notch physical training, exercise scientists and strength training and conditioning personnel have spent much time comparing and contrasting different modes, frequencies, and intensities of exercise to receive maximum output. “To be effective, the strength and conditioning coach must cultivate a movement oriented philosophy where training drills are progressively coupled with performance tasks to be executed in simulated competitions. Yet at some point during training, game like skills must be executed in game-like situations to get the best results” (59), p. 44).

PURPOSE OF REVIEW
The purpose of this review is to examine what current and past literature has found relating to the necessary strength training and conditioning development for collegiate women’s volleyball training. More specifically it will examine previous methods to determine how to maintain conditioning level gains from off-season training in the area of muscular strength and endurance, power, agility, and anaerobic capacity during a competition season of an annual periodized training cycle.

In an attempt to understand if a relationship between periodization of strength training and conditioning and the maintenance of conditioning levels during competition
season exists, a review of the following areas will be discussed: A volleyball athlete profile, the physiological and energy system requirements for volleyball players, importance of periodization, frequency of strength training and conditioning necessary during a competition season to maintain off-season gains, and the relevance of utilizing field tests.

**SCOPE AND LIMITATIONS**

More specifically, this literature review will concentrate on the parameters that are important for two phases of an annual periodized collegiate volleyball season. These phases will be examined to determine the necessary frequency of strength training and conditioning required during a competition phase in order to maintain strength training and conditioning gains acquired during the off-season, specifically the 13 weeks prior to pre-season.

This review will look at the bodily movements required to play volleyball, the physiological and energy system requirements for volleyball players, importance of periodization, frequency of strength training and conditioning necessary during a competition season to maintain off-season gains, and the relevance of field testing.

**JUSTIFICATION OF STUDY**

The majority of research in the areas of strength training and conditioning in general has focused on the use of male subjects for short periods of time, such as 13 weeks or less. However, it is worth considering whether similar affects would manifest themselves in collegiate females. Therefore, it is important to study the strength training and conditioning effects on females in order to learn more about how pre-season and
competition seasons conditioning and technical training affect their strength training and conditioning levels.

ATHLETE PROFILE

Volleyball is commonly described as a high speed, explosive, and powerful sport (33). The sport of volleyball is made up of movements requiring repeated maximal or near maximal vertical jumps, frequent change of direction sprints, diving to make a save, and repeated overhead movements utilized in spiking or blocking (11,26). Furthermore, volleyball athletes are required to generate high levels of force quickly for offensive movements for spiking or performing an approach jump. The same force requirement for offensive movements is necessary for the body to absorb a significant amount of force when completing defensive motions such as diving, landing, or blocking a spike (11). The production of the force necessary to execute technical play during practice and competition may also increase the risk for injuries if the body is not physically conditioned to take on such a demand. A well designed strength training and conditioning program plays an important role in reducing injury (33).

The high-speed and force requirement in volleyball are needed as the average play in volleyball lasts about six seconds, which is followed by an average rest period of 14 seconds, not including player substitutions or time-outs (33). Additional research confirming the duration of an average rally found that sets consist of repeated rallies averaging seven to 10 seconds in duration, separated by rest periods averaging 12 to 14 seconds (54). Thus, an entire collegiate volleyball match, which consists of winning the best three of five sets, typically has duration of from 90-120 minutes.
Past observational methods have illustrated the unique patterns and movements needed to play volleyball. Belyaev (9) reported that an elite male volleyball player executed 250 to 300 high-power motor acts during a five game match. Of those movements 50 to 60% were jumps, 27 to 33% were dashes, and 12-16% were dives. Other research found that senior high school men made about four changes of direction per 10 seconds of rally time (54).

**PHYSIOLOGICAL CHARACTERISTICS**

Past and current research has identified two key trainable components to positional and team success at the collegiate level of volleyball. The identified trainable areas incorporate match semantics and sport specificity incorporating the physiological energy demands. When considering the aforementioned match semantics and movements along with the physiological demands the trainable areas for volleyball are suggested as being agility, explosive muscular power, muscular strength and endurance, and the ability to utilize a high anaerobic capacity for an extended period of time (33).

Applying mechanical and metabolic specificity as the basis for designing training programs for volleyball can positively influence the transfer of training effects from the weight room to the court (29). In order to meet the unique physical demands of volleyball a high level of conditioning is required (26).

**Muscular Strength**

Training for muscle hypertrophy, power and strength is the focus of the majority of a volleyball attacker’s physiological and metabolic physical conditioning (33). For volleyball training, Hedrick (33) stated that there is a positive relationship between
muscle size and muscle strength, as well as a positive relationship between strength and power.

Training for strength requires high resistance, near maximal muscular contractions over a small number of repetitions, coupled with full recovery between sets. This type of training protocol leads to increases in the cross-sectional area of the exercised muscles, with type II fibers increasing more readily and at a faster rate than type I fibers (70).

Training for strength is important for power athletes who are dependent on strength and power because type II fibers contract with greater velocity than do type I fibers. There is also an indication that the strength per unit of type II fibers may be twice that of type I fibers (55).

Power

Next to the development of muscular strength, training for power is critical. More recently, resistance training protocols that address velocity of movement have been developed to enhance muscular power rather than strength (53). This type of training is necessary for the continuous, repetitive jumping, blocking, spiking movements that require maximal force production and little time for recovery. Therefore it is necessary that volleyball players incorporate power training into their strength training regimen.

Vertical jump production and reaching peak maximal height are important qualities for every player on the volleyball court to exhibit. Vertical jump ability is critical for success in volleyball and is displayed during the jump set, jump serve, blocking, and spiking. A successful player must not only be able to jump high but must
also be able to reach that height quickly. This requires an ability to generate power in a very short time (61).

Developing high levels of power can be achieved by developing strength and power through fast, explosive movements at high intensities for limited time (68). Explosive training will enhance the rate of force development of type II muscle fibers through neuromuscular adaptation, which theoretically would reduce movement time during the jump (68). A common method of power training in sports such as volleyball is by using plyometric activity. McCurdy et al. (49) found that increasing power performance in volleyball players can be done by performing a combination of strength and plyometric exercises.

**Agility and Speed**

Volleyball hitters must be able to react quickly to the pace of the game which requires that they have a quick ground contact phase during change of direction (33). Barnes et al. (8) reported that a significant inverse relationship exists between ground contact time and maximum sprint velocity. A strong correlation of high fast twitch muscle fiber content and maximal running velocity was also found. These findings suggest that speed is a component that influences a volleyball player’s ability to move quickly which can be trained through speed, agility, and plyometric training.

In addition to speed, lateral movements should also be an emphasis in sport specific strength training and conditioning programs for volleyball players. Hedrick (33) stated typically, most strength training movements such as cleans, squats, and forward lunges, occur in the sagittal plane. However, most athletic events, including volleyball, are a mixture of straight ahead and lateral movements. In volleyball, lateral movements
include a middle blocker sliding laterally to make a block or a defensive specialist lunging and diving laterally to make a save. If athletes train only in the sagittal plane, they may not be adequately prepared for optimal lateral movement capabilities. To compensate for this, athletes should incorporate lateral movements in weight training sessions, plyometric exercises, and speed work.

**Anaerobic and Aerobic Requirements**

Measurements of postgame lactate levels indicate the energy source for volleyball players is mainly supplied by the adenosine triphosphate (ATP) and phosphocreatine stored in the muscles. This requirement is consistent with the match which is characterized by short rallies that incorporate quick, high-power movements, with a longer rest in between. There is little involvement of anaerobic glycolysis, therefore little lactate is produced. Re-synthesis of phosphagen occurs aerobically during the rest intervals thus minimizing the need for anaerobic glycolysis (11,16,42,69).

Incorporating sport specific movements and timing into metabolic conditioning indicates that training should consist of jumping, running, and or diving, involving frequent changes of direction, followed by 10-15 seconds of rest. In order to prepare the players for rallies that exceed 15 seconds in duration some of the training activities should last 20-45 seconds (11,33). Intensity and duration of training activities and duration of recovery periods should be controlled in order to train the aerobic and anaerobic thresholds and to avoid stressing the lactic acid anaerobic metabolism too heavily (11,69). Stressing the phosphocreatine system and aerobic systems but not anaerobic glycolysis requires that training consist of sets or repetitions with sufficient rest between sets to avoid an excessive buildup of lactic acid (9).
Incorporating sport specificity in training the metabolic system is crucial to mimicking a proper match scenario. This can be executed by implementing the proper work to rest ratio. Hedrick (33) reported that an entire volleyball match generally consists of 50 rallies per game. In order to incorporate sport specificity in metabolic training, work time should generally consist of 50 or more repeats lasting 5-10 seconds in order to prepare the aerobic and anaerobic thresholds. Adequate rest in between sets is very important in order to not over stress anaerobic metabolism.

The benefits of incorporating sport specificity to the movements and metabolic training for sports are endless. If the training regimen is specific to the energy systems involved in the game and the movements used in training are specific to volleyball, it is possible to overload the neuromuscular system so that the athlete is trained to jump higher, to run faster, and to change directions more quickly just by participating in practice (11,33). Training programs which focus on this could enable the volleyball athlete to perform with greater power, minimize decrements in performance due to fatigue, and practice the specific skills used in the game more efficiently (11).

**PERIODIZATION**

In addition to metabolic and sport specificity, the process of periodization is a component of general and collegiate strength training and conditioning programs. The activities that are necessary for sport specificity and overloading of the trained muscles are periodized over an annual cycle so that gains are maximized and overuse and injury are minimized.

Periodization is concerned with variation of training. This variation suggests it’s unlikely that a single optimal periodized training scheme exists that will elicit superior
improvements when applied for extended periods. Rather, it seems possible that a range of periodization strategies implemented in combination will produce the best results throughout a long-term training cycle (18,60).

A goal of periodization is to vary the training program at regular time intervals in an attempt to bring about optimal gains in strength, power, motor performance, and muscle hypertrophy (18). A second goal of periodized strength training is to optimize training during short periods of time such as weeks and months, as well as long periods of time including years, an athletic career, or a life time. In the case of a competitive athlete, another goal is to peak the physical performance at a particular point in time, such as for a major competition and or end of season championship tournaments (12,18).

Multiple training variables are manipulated to optimize strength training and conditioning programs. These variable include: the number of sets performed of each exercise, number of repetitions per set, exercises performed, number of exercises performed per training session, rest periods between sets and exercises, resistance used for a set, type of muscle action performed eccentric, concentric, or isometric, and number of training sessions per day and per week (18).

Periodized training is characterized by high initial volume and moderate intensity. Over the course of a two to six week phase of the annual periodization training program, intensity progressively increases while volume inversely decreases until a peak is reached at the end of the training period. This change in training focus is done to maximize strength gains and minimize overtraining and staleness (12,66).

In contrast, non-periodized models are typically characterized by three sets at a constant intensity or load. Maximal effort intensity equal to or greater than six repetitions
has been reported to represent the optimal training range for strength development (2,10). Utilizing a non-varied design of constant intensity and volume elicits strength gains but does not guard against possible overtraining, especially during a competition season (19,67).

Volleyball training and other team sports require several different training goals. These may include hypertrophy, maximum strength, explosive power, metabolic conditioning, and injury prevention (31). Therefore there is a need for planned variations in the training program to systematically shift the emphasis and focus to promote these different training effects at different phases of the annual training cycle (27).

One way in which periodization can increase physical capacity in volleyball players is by an increase in vertical jumping ability which may enhance performance. Research utilizing a periodized weight training program has resulted in greater gains in vertical jump ability or motor performance than non-periodized training (18). An additional study by Fleck (18) concluded that sports such as football, volleyball, and shot put which rely on leg strength and power supported the implementation of a periodized weight training program.

**IMPORTANCE OF OFF-SEASON TRAINING**

The level of physical conditioning in which a player enters a season may have an imperative effect on the physical performance during the course of the competition season. Plisk and Gambetta (59) found that during the course of a competition season, volleyball players are exposed to a variety of physical and psychological stresses from practice, conditioning, and competition. Ability of the athletes to recover following such activities can ultimately affect the quality of performance. Without appropriate rest and
recovery, intensive pre-season and competition season conditioning may decrease performance.

Adherence to off-season physical training is important for pre-season training. Kraemer et al. (41) reported that female soccer players that entered the season with low circulating concentrations of testosterone and elevated levels of cortisol experienced reductions in performance during the competition season. This suggests that athletes who try to get in shape quickly, such as six to eight weeks prior to the start of pre-season, may negatively influence their physical conditioning levels. These detrimental effects of inappropriate training do not appear to be unloaded during the competition season and catabolic activities can predominate (41).

Collegiate soccer and volleyball both have fall competition seasons. The competition phase is preceded by an off-season and preparatory season training which takes place during the summer months. This suggests that volleyball players could have a similar physiologic response due to the similar competition season and physiological demands of the two sports. Soccer and volleyball players alike should have a planned program of conditioning that does not result in an acute overtraining prior to preseason.

FREQUENCY OF STRENGTH TRAINING AND CONDITIONING

For the general population, the adaptation to training seems to be dependent on factors such the initial level of fitness, training intensity, volume and frequency. However, in highly trained athletes, the level of strength training and conditioning achieved in the off-season phase of an annual training cycle is a determining factor if gains will be maintained throughout the competition phase (32,51). This suggests that
adherence to the off-season training program is of paramount of importance to the maintenance of strength during the competition season.

Time constraints imposed by the high volume of team practices and other skill training are common to all professional and collegiate team sports, thus the time efficiency of physical preparation is of utmost importance. Assuming that both the pre-season and competition season programs occur during the 20 hour per week NCAA allotted time period, the biggest planning considerations are the changes in priorities and the gauging of overall workload as teams move from one phase of the annual cycle to another (32).

As the playing season approaches, the focus inevitably shifts to tactical aspects, with a greater number of team practices preparing for the upcoming events of the competition season (32). During the competition phase the athletes’ training focus shifts from a high volume of strength training and conditioning and a low volume of skill and technical training to a low volume of strength training and conditioning and a high volume of skill and technical development (32). This shift in priority requires the in-season strength training and conditioning program to be comprised of fewer total sets while still including one set of high intensity per exercise. Hedrick (32) found that competition season strength training and conditioning programs that prescribe sets of higher repetitions and lower intensity actually overload the athlete with volume and provide no stimulus for the body to maintain the previously hard earned levels of strength and power.

During the competition phase, match play and the corresponding travel have been added to a schedule that already includes practice and lifting. Competition usually
receives top priority over further development of sports skills and additional strength training and conditioning. Even if the coaching staff has committed to balance the skill and conditioning training, it becomes increasingly more difficult because the travel and competition schedule become the priority and dictate the amount of time remaining for other weekly training sessions (32).

In order to maintain strength gains from off-season training during the competition phase, it is important that strength training and conditioning professionals take into consideration the amount of skill training, physical conditioning, and rest. When a player is both training and competing, the dynamic homeostatic balance created between anabolic and catabolic processes within the muscle can ultimately influence muscular force characteristics and, therefore, affect the quality of a player’s performance (22).

Starters and non-starters are susceptible to decrements in performance capabilities if entering the season with catabolic processes predominating. With the continued high intensity stress experienced throughout the season, the consequence of entering the competition season in this nature is reflected as a chronic catabolic environment for the neuromuscular system. Such a catabolic physiological status results in significant losses in muscular force which are manifested as decreases in speed, vertical jump height, and strength, all of which are of superior importance to volleyball. Balancing training and rest is challenged during the competition season but is important for the exclusion of overtraining and having the team peak at the wrong time. The latter stages of a season are critical in determining the fortunes of a team, as it is during this period that play-offs and championship tournaments are played (41).
Research using college aged men comparing a periodized strength training program to a non-periodized strength training program for six weeks, found that the periodized subjects who focused on a progression from high volume and low intensity to lower volume and higher intensity training significantly increased their back squat strength and vertical jump over the non-periodized group (18). Another study utilizing ROTC cadets examined the manipulation of training intensity on strength and body composition. The results indicated a significant improvement in body composition, strength, and speed in the subjects that increased their intensity when compared to subjects that used a constant intensity over 10 weeks (62).

RELEVANCE OF FIELD TESTS

Field tests can be used in order to assess the physical response that athletes have to conditioning and particularly how it is affected during different phases of a periodized annual cycle. The utilization of field tests supplies strength training and conditioning personnel with baseline measurements, uses minimal equipment, are cost effective, can test large groups at the same time, and are easily transported to areas that could be more sport specific (14). Baseline measurements provide personnel and coaches with a standard for assessing athletic talent, screening possible health risks due to strenuous exercise, to reveal a specific weakness, and provide data for outlining individualized exercise prescriptions. They can also be helpful in allowing coaches and athletes to observe progress in tests which are directly related to the event or skill and provide a measure of fitness level and identify areas that need improvement. Even though the field test is based on a skill that is related to a particular sport, they do not appear to be a good predictor of performance (3,7,14,24).
A task analysis allows personnel to decide what the metabolic and physical requirements are for each specific position or event in their respective sport. After the analysis, field tests should be chosen or developed that measure the components of the task that will add to success during the performance of the athlete (14,28).

For testing, the protocol selection must be specific to the athletic activity for which the athlete is training (52). When field tests are used to distinguish between players of different abilities or gain baseline measurements, tests that are most sport-specific tend to be given the greatest credence. The approach jump touch height may be a reflection of their vertical jump height in the middle of a match. This suggests that the vertical jump height is an important sport specific field test for volleyball players (29). The following field tests may be an accurate assessment of sport-specific skills for volleyball players.

**Sit-Ups**

A 60 second sit-up test is suggested to be a standard measure of muscular strength and endurance in sport and athletic testing (1,13,37,40,46). Sit-up tests are professed to indicate core strength and therefore core stability and support of the lower back (17). Core strength enables volleyball players to have better control over their body, adds power to attacking and jump serving, and is needed to perform resistance exercises such as deadlifts, cleans, and back squats (33).

**1RM Back Squat**

The back squat is a commonly used exercise that stimulates the largest, most powerful muscles in the body and may be the best test of lower-body strength. Key muscles involved are the quadriceps, hamstrings, gastrocnemius, and the gluteus maximus. The squat also relies on muscle activity at both the hip and ankle joints and
recruits the abdominals and spinal erectors as well (30). The 1RM back squat is thought to provide a good indication of an athlete's dynamic strength levels in sport and athletic testing (18,57,71).

**T-Test**

Agility, leg power, and leg speed are believed to be important physical components necessary for successful performance in many sports and recreational activities (23). The T-Test appears to be highly reliable at measuring those components in addition to measuring 4-directional agility and body control (64). It also evaluates the ability of the body to change directions rapidly while maintaining balance without loss of speed. Acceleration and agility are very important in volleyball, for moving with balance quickly around the court (11). Measurements of leg speed, leg power, and agility and may be used to differentiate between those of low and high levels of sports participation (58).

**Vertical Jump Test**

The generation of lower body explosive power can be considered an important factor in many athletic activities. Power, is crucial for the performance of different sports actions especially those involving changes in direction, accelerations, jumping, and sprinting (35). The vertical jump is a commonly used measure of speed-strength or power in volleyball players and is critical for success in volleyball (61). Multiple similarities have been found between the movements and muscle recruitment necessary to execute the vertical jump and those required during volleyball match play (18,48).
**300 Yard Shuttle Run**

The 300-yard shuttle run has been recommended as a reliable test of the anaerobic lactic endurance capacity and agility of an athlete (4). The use of this test is more beneficial than a straight line run in any sport in which rapid changes of direction in both the vertical and horizontal planes of movement are required. This test is also used to assess the athlete’s ability to accelerate between marked lines and to rapidly change direction which is necessary for volleyball players to do at a high speed (11). There is some interplay of the phosphagen system within this particular test, especially in relations to the short burst of acceleration immediately after the turn to the next line which is necessary for long rallies in volleyball (36,43,44,45).

**CONCLUSION**

Based on the research presented in this review, a sport specific strength training and conditioning program has proven to be a necessary mode for the improvement on the skills necessary for increasing performance in sports and recreational exercise. Previous research has primarily focused on the use of males as subjects however very few have used women.

In addition to identifying the important physiological traits and skills training necessary for volleyball players, literature has illustrated that the implementing of periodization into phases of an annual periodization cycle can help athletes to peak their performance for a particular point in time. The inverse relationship of volume and intensity that is incorporated into periodized programming helps athletes maximize their practice and competition season by not over training and peaking their performance for weekend competitions and post-competition season tournament play.
The inverse relationship of volume and intensity in periodization also allows for a decrease in strength training and conditioning frequency during the competition season. This is especially important during the competition season as the focus shifts from off-season strength training and conditioning focus to a skill and technical training focus. Current research has found that conditioning levels can be maintained if the frequency is decreased to two days per week.

Results from an athletic profile illustrate that anaerobic capacity, agility, muscular power, strength and endurance are important physiological components of volleyball players. Based on the physiological and body mechanics necessary for volleyball players, field tests have been identified and can be incorporated for testing to gather baseline information on volleyball athletes.

Despite the current research, the information regarding maintenance of conditioning levels during a competition season is limited as it pertains to female athletes, specifically collegiate women’s volleyball players. Further, most studies using collegiate athletes are tied to an academic semester. Longer studies incorporating women are necessary to evaluate if a relationship can be established between off-season and competitions season conditioning levels. In addition, reliability of testing between collegiate women’s volleyball players could be established with consistency in field tests used for measuring conditioning levels.
CHAPTER III
CONCLUSION AND RECOMMENDATION

SUMMARY AND CONCLUSION
The purpose of this investigation was to compare conditioning levels between two phases of a periodized annual training cycle. The intent was to determine if off-season conditioning levels could be maintained with a decrease in the frequency of strength training and conditioning training sessions during the competition season. Subjects were required to adhere to two 13 week training programs, one during the off-season and the other during the competition season.

Measurements were taken from a battery of tests for baseline, post off-season, and post-competition season measures. The tests used were the vertical jump height, 1 minute sit-up test, T-Test, 300 yard shuttle run, and 1RM back squat. Results from these tests measured the subjects’ muscular strength, endurance and power, agility, and anaerobic capacity.

The findings of this study indicate that off-season strength training and conditioning levels can be maintained during the competition season by decreasing the frequency of training to three days per week. A repeated measure analysis of variance was used to compare the differences between subjects for the different tests; alpha was set at the 0.05 level.

Measurements that reflect muscular strength, endurance, and power such as the 1RM back squat, vertical jump, and 1 minute sit-up illustrated a significant increase in scores between the baseline and OS testing and were maintained throughout the CS. In addition, the 1RM back squat scores significantly increased throughout the CS. The
vertical jump and 1 minute sit-up scores were maintained through the CS. The T-Test and
the 300 yard shuttle run indicated a significant decrease in time ran from baseline through
OS however, the T-Test illustrated a significant increase during the CS and the 300 yard
shuttle time was the same.

RECOMMENDATION

Based on the conclusion of this study and literature review, it would be in the best
interest of strength training and conditioning personnel and coaching staff to follow the
following recommendations for future conditioning level responses to off-season and
competition season training sessions.

1. Take a concerted look at the current value placed on the strength training and
conditioning for volleyball at the annual training level. Further, evaluate the emphasis
that is put on strength training and conditioning during the competition season.

2. Examine the current time spent for technical, skill training, strength training and
conditioning and rest. Is the combined physical activity the team is engaged in ensuring
them peak physical performance for competition dates?

3. Specific training for agility and/or speed should either be incorporated into practice or
one of the training days.

4. If strength training and conditioning is a major focus of the current annual training
cycle, determine if the current time spent during the competition season could be utilized
more efficiently and ultimately decreased. If the time spent training could be decreased,
teams could focus on other duties that accumulate towards the NCAA countable hours.

5. Additional research using females as subjects for periodization studies taking a close
look at total volume for an annual plan.
REFERENCES


APPENDIX A

INFORMED CONSENT FORM

NORTHERN MICHIGAN UNIVERSITY
DEPARTMENT OF HPER

CONSENT TO ACT AS A HUMAN SUBJECT

Subject Name (print):__________________________________Date:_____________

1. I hereby volunteer to participate as a subject in exercise testing. I understand that this testing is part of a study titled: A comparative study between a traditional strength training and conditioning program and The P90X Total Body Program in collegiate women volleyball players. The purpose of this study is to determine if there is a physiological difference in training between the P90X Total Body Work Out and a strength training and conditioning program designed for collegiate volleyball players.

I hereby authorize Amy Molenaar and/or assistant/s as may be selected by her to perform on me the following battery of tests:

- 7 Site Skin Fold Test (Body Composition)
  My body composition will be determined by using a Skinfold Caliper. Measurements will be taken from the chest, thigh, abdomen, suprailium, midaxilla, subscapula, and calf by measuring the thickness of a small section of skin pinched between fingers.

- Vertec Vertical Jump Test (Anaerobic Power)
  I will begin by reaching my hand above to measure my standing height. I will then lower my right hand and, without a preparatory or stutter step, flex my knees and hips, bringing my trunk forward and downward, and swing my arms backward. At the highest point in the jump, I will reach up with my right hand and tap the highest possible vane of the Vertec. The score is the vertical distance between the heights of the highest vane tapped during the standing vertical reach and the vane tapped at the highest point of the jump.

- T-Test (Agility)
  On a line three cones (C, B, and D) should be arranged in a line so that they are separated by 5 yards. Cone A is 10 yards away from cone B, making the shape of the letter T. I will warm up prior to the test. The test will begin with me standing at point A. On the “Go” command, I will sprint forward to point B and touch the base of the cone with my right hand. I will then shuffle to the left 5 yards and touch the base of the cone at point C with my left hand. When shuffling, I will...
face forward and will not cross my feet. I will then shuffle to the right 10 yards and touch the base of the cone at point D with my right hand. I will then shuffle to the left 5 yards and touch the base of the cone at point B with my left hand, then run backward past point A, at which time the timer will stop the watch. I will repeat the test twice. If I do not touch the cone, cross one foot over the other, or do not face forward the entire time, another trial will be performed.

- **1 Rep Max Squat Test (Muscular Strength)**
  I will warm up with a light resistance that easily allows 5-10 repetitions. I will then rest for 1 minute. Next I will warm up with an estimated load that will allow me to complete 3-5 repetitions by adding 30-40 pounds or 10-20% of the initial weight. I will then rest for 2 minutes. Next, I will lift an estimated conservative, near maximum load that will allow me to complete 2-3 repetitions by adding 30-40 pounds or 10-20% of the second load. I will then rest for 2-4 minutes. Next, I will increase the load 30-40 pounds or 10-20%. This attempt will be my 1 RM. If it is successful, I will receive a 2 to 4 minute rest period and have opportunity to administer the last step again. If the lift was not successful, the weight will be decreased and the last step will be attempted again.

- **Sit up test (Muscular Endurance)**
  On the “Go” command, I will raise my upper body to the up position with the elbows touching my thighs. I will then lower my body until the upper portion of the back touches the mat. The head, hands, arms, and elbows do not have to touch the ground. With each repetition, the tester calls out the number of correct repetitions performed so far. The test is scored by how many sit-ups can properly be performed in 1 minute.

- **300 Yard Shuttle Test (Anaerobic Capacity)**
  I will be paired off with someone of similar capabilities. On the testers signal, I along with my partner I will sprint to the 25 yard line and return to the starting line for a total of six round trips for a total of 300 yards. Foot contact must be made on the starting line and the 25 yard line when changing directions. On completion of the first trial, I will have a five minute rest interval until the next trial. As I finish the first trial, I may walk and stretch, but must stay alert for the starting time on the second course. After five minutes of rest, I along with my partner will begin the second course.

- **1.5 Mile Run (Aerobic Capacity)**
  I will be timed for running a pre determined 1.5 mile course.

2. The procedures outlined in paragraph 1 have been explained to me.

3. I understand that the procedures described in paragraph 1 involve the following risks and discomforts: temporary muscle pain and soreness is expected. There is a possibility of abnormal changes in my heart rate or blood pressure or even of a heart attack during the tests. However, I understand that my heart rate will be monitored during testing and that I can terminate any test at any time at my discretion. Moreover, I should cease any test or procedure if I experience any abnormalities such as dizziness, light headedness, or shortness of breath, etc.
4. I have been advised that the following benefits will be derived from my participation in this study: aside from the educational benefit of learning about fitness testing or about my fitness level, there are no direct benefits to me.

5. I understand that Amy Molenaar and/or appropriate assistants selected by her will answer any inquiries that I may have at any time concerning these procedures and/or investigations.

6. I understand that all data, concerning myself will be kept confidential and available only upon my written request. I further understand that in the event of publication, no association will be made between the reported data and myself.

7. I understand that there is no monetary compensation for my participation in this study.

8. I understand that in the event of physical injury directly resulting from participation, compensation cannot be provided.

9. I understand that I may terminate participation in this study at any time without prejudice to future care or any possible reimbursement of expenses, compensation, or employment status. In addition, I understand that if I chose to terminate my participation in this study that my relationship with my coaches or teammates will not be affected.

10. I understand that if I have any further questions regarding my right as a participant in a research project I may contact Dean Cynthia Prosen of the Human Subjects Research Review Committee of Northern Michigan University (906) 227-2300. Any questions I have regarding the nature of this research project will be answered by Amy Molenaar at amolenaa@nmu.edu (906) 227-1173 or Dr. Randall Jensen rajensen@nmu.edu at (906) 227-1184.

Subject’s
Signature: ___________________________________________ Date: ________________

Witness
Signature: ___________________________________________ Date: ________________
## OFF-SEASON WORKOUT PROGRAM

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Notes</th>
<th>Focus</th>
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<tbody>
<tr>
<td>1</td>
<td>5/05/08</td>
<td>Track A Begins</td>
<td>Hypertrophy</td>
</tr>
<tr>
<td>2</td>
<td>5/12/08</td>
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<td>Hypertrophy</td>
</tr>
<tr>
<td>3</td>
<td>5/19/08</td>
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<td>Basic Strength</td>
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<tr>
<td>4</td>
<td>5/26/08</td>
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<tr>
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<td>6/02/08</td>
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<td>6</td>
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<td>8</td>
<td>6/23/08</td>
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<td>13</td>
<td>7/28/08</td>
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**Hypertrophy (Track A)**

DB – Dumbbell; MB – Medicine Ball; DD – Density Disk; RG – Reverse Grip

**Dates:** May 5 – May 18

**Cycle:** Hypertrophy

**Goal:** Increase blood flow and stimulation of muscle, tendon and ligaments fibers; slow tempo to let muscles adapt to training.

**Length:** 2 weeks

**Intensity:** Light to Moderate (55-60%)

**Rest:** 30 seconds

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<th>Monday</th>
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<tr>
<td>Power Clean Pull 4 x 6</td>
<td>Bench Press 3 x 12</td>
<td>Hang Clean Pull 3 x 8</td>
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<tr>
<td>Quick Squat 3 x 15</td>
<td>Lat. Pullover 2 x 15</td>
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<td>Dead Lift 3 x 8</td>
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<td>Block Jump 3 x 8</td>
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<td>DB Low Row 3 x 15</td>
<td>Tuck Jump 3 x 8</td>
<td>Bent Over Reverse Fly 2 x 15</td>
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<tr>
<td>Forward Step-Up 3 x 10 (2)</td>
<td>Seated DB Shoulder Press 3 x 12</td>
<td>Quick Squat 3 x 10</td>
<td>DB Bench Press (incline) 2 x 12</td>
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<tr>
<td>Leg Curl 3 x 15</td>
<td>Side Lateral Raise 2 x 15</td>
<td>Leg Curl 3 x 10</td>
<td>Straight Arm Lat. Pulldown 3 x 15</td>
</tr>
<tr>
<td>Walking Lunge 2 x 10 (2)</td>
<td>Upright Row 3 x 10</td>
<td>Overhead Squat 3 x 12</td>
<td>Push Ups 1 x 8</td>
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<tr>
<td>Standing Calf Raise 3 x 15</td>
<td>Bench Dips (feet on SB) 3 x 10</td>
<td>DB Straight Leg Press 3 x 12</td>
<td>Int./Ext. Rotation 3 x 10 (2)</td>
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<td>DB Curl 3 x 15 (2)</td>
<td>Alt. Angle Lunge 3 x 10 (2)</td>
<td>Biceps Cable Curl 3 x 12</td>
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<tr>
<td>Cardiovascular Scheme 1</td>
<td>DB Triceps Kickbacks 3 x 15 (2)</td>
<td>Standing Calf Raise 3 x 10</td>
<td>Triceps Cable Pushdown 3 x 12</td>
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<td>Core Scheme 2</td>
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<td>Scheme 2</td>
<td>Scheme 1</td>
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# Basic Strength (Track A)

**Dates:** May 19 – June 01  
**Cycle:** Basic Strength  
**Goal:** Increase in muscle force production, overload muscle during lifting to produce muscular adaptation.  
**Length:** 2 weeks  
**Intensity:** Heavy (80-85% 1RM)  
**Rest:** 2 minutes

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<td>Squat</td>
<td>DB Shoulder Press</td>
<td>To Box</td>
<td>DB Fly</td>
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<td>Bent Over Lat. Raise</td>
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<td>Barbell Curl</td>
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<td>Seated DB Shoulder Press</td>
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<td>Core</td>
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<td>Core</td>
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### Power (Track A)

**Dates:** June 2 – June 15  
**Cycle:** Power  
**Goal:** Overload the muscle with weight and pace to increase muscle power. Pace is two counts down and then two counts up.  
**Length:** 2 weeks  
**Intensity:** Very Heavy (87-95% 1RM)  
**Rest:** 2 minutes; *Supersets, two lifts back to back with 2 minutes rest in between sets

<table>
<thead>
<tr>
<th>Monday</th>
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<th>Thursday</th>
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<td>Squat</td>
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<td>Clean Deadlift</td>
<td>4 x 5</td>
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<td>Forward Step Up</td>
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<td>Lateral Lunge</td>
<td>MB Set Press</td>
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<td>Standing Calf Raise</td>
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<tr>
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<td>Scheme 1</td>
<td>Flexibility</td>
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### Download (Track A)

Dates: June 16 – June 22

Cycle: Taper

Goal: Maintenance of strength and power gains from Track A prior to beginning Track B

Length: 1 week

Intensity: Moderate (60-65%)

Rest: 30 seconds

<table>
<thead>
<tr>
<th>Tuesday</th>
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<tbody>
<tr>
<td>Quick Squat (DD) 4 x 15</td>
<td>Power Clean 3 x 5</td>
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<td>Leg Curl (SB) 4 x 12</td>
<td>Push Press 3 x 5</td>
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<tr>
<td>Jump and Reach 3 x 10</td>
<td>Squat 3 x 10</td>
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<tr>
<td>Tuck Jump 3 x 10</td>
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<td>Seated Cable Low Row 2 x 12</td>
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<td>Push ups (DD) 2 x 10</td>
<td>DB Shoulder Press (SB) 2 x 12</td>
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<td>Pull Ups (SB) 2 x 6</td>
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<td>Straight Arm Lat. Pulldown 2 x 15</td>
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<tr>
<td>DB Upright Row to Press (DD) 3 x 12</td>
<td>Side Lateral Raise 2 x 15</td>
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<td>Core Scheme 1</td>
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**Hypertrophy (Track B)**

**Dates:** June 23-June 29

**Cycle:** Hypertrophy

**Goal:** Increase blood flow and stimulation of muscle, tendon and ligaments fibers; slow tempo to let muscles adapt to training.

**Length:** 1 week

**Intensity:** Moderate (60-65%)

**Rest:** 30 seconds

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
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<tr>
<td>Power Clean Pull 3 x 15</td>
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<td>Push Press 3 x 8</td>
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<td>Bent Over Reverse Fly 12-10-8</td>
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**Basic Strength (Track B)**

**Dates:** June 30 – July 13  
**Cycle:** Basic Strength  
**Goal:** Increase in muscle force production, overload muscle during lifting to produce muscular adaptation.  
**Length:** 2 weeks  
**Intensity:** Heavy (80-90% 1RM)  
**Rest:** 2 minutes

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<th>Tuesday</th>
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</thead>
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<td>Close Grip Lat. Pulldown 12-10-8-6</td>
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<td>Overhead Squat</td>
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<td>DB Shoulder Press 12-10-8-6</td>
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<td>Barbell Curl 3 x 10</td>
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**Power (Track B)**

**Dates:** June 14 – June 27

**Cycle:** Power

**Goal:** Overload the muscle with weight and pace to increase muscle power. Pace is two counts down and then two counts up.

**Length:** 2 weeks

**Intensity:** Very Heavy (87-95% 1RM)

**Rest:** 2 minutes; *Supersets, two lifts back to back with 2 minutes rest in between sets

<table>
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<tr>
<th>Monday</th>
<th>Tuesday*</th>
<th>Thursday</th>
<th>Friday</th>
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<tr>
<td>Power Clean 4 x 4</td>
<td>Bench Press 10-6-5-4-3</td>
<td>Power Clean 1 x 5, 4 x 3</td>
<td>DB Incline Press 3 x 8</td>
</tr>
<tr>
<td>Overhead Squat 2 x 10</td>
<td>Seated Cable Low Row 1 x 10, 4 x 5</td>
<td>Push Press 3 x 6</td>
<td>DB Low Row 3 x 8 (2)</td>
</tr>
<tr>
<td>Squat 10-6-5-4-3</td>
<td>DB Upright Row to Press 3 x 8</td>
<td>Lateral to Box 6 (2)</td>
<td>DB Fly 3 x 10</td>
</tr>
<tr>
<td>Deadlift 4 x 5</td>
<td>Bench Dips (SB) 3 x 10</td>
<td>Depth Jump 8</td>
<td>Int./Ext. Rotation 2 x 10 (2)</td>
</tr>
<tr>
<td>Forward Step Up 3 x 8 (2)</td>
<td>DB Pullover 3 x 8</td>
<td>Explosion Squat 3 x 8</td>
<td>Bent Over Lat. Raise 3 x 10</td>
</tr>
<tr>
<td>Standing Good Morning</td>
<td>Straight Arm Lat. Pulldown 3 x 10</td>
<td>Deadlift 3 x 6</td>
<td>MB Bench Press (SB) 3 x 8</td>
</tr>
<tr>
<td>Quick Squat (DD) 2 x 15</td>
<td>RG Barbell Curl 3 x 8</td>
<td>Overhead Walking Lunge 3 x 10 (2)</td>
<td>Pull Ups (SB) 3 x 8</td>
</tr>
<tr>
<td>Leg Curl (SB) 2 x 12 (2)</td>
<td>Tri Cable Pushdown 3 x 8</td>
<td>Standing Good Morning Core 3 x 10</td>
<td>DB Standing Military Press</td>
</tr>
<tr>
<td>Standing Calf Raise 2 x 10</td>
<td>Core Scheme 2</td>
<td>Standing Good Morning Core Scheme 1</td>
<td>DB Curl 2 x 12 (2)</td>
</tr>
<tr>
<td>Core Scheme 1</td>
<td>Cardiovascular Scheme 2</td>
<td>Cardiovascular Scheme 1</td>
<td>Single Arm Tri Cable Pushdown</td>
</tr>
<tr>
<td>Cardiovascular Scheme 1</td>
<td>Flexibility Scheme 1</td>
<td>Flexibility Scheme 1</td>
<td>Core Scheme 2</td>
</tr>
<tr>
<td>Flexibility Scheme 1</td>
<td></td>
<td></td>
<td>Cardiovascular Scheme 2</td>
</tr>
</tbody>
</table>

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## Maintenance (Track B)

**Dates:** June 28 – August 3  
**Cycle:** Maintenance  
**Goal:** Maintain strength gains.

**Length:** 1 week  
**Intensity:** Moderate (60-65% 1RM)  
**Rest:** 30 Seconds

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Clean 4 x 6</td>
<td>Bench Press 3 x 12</td>
<td>Power Clean 3 x 8</td>
<td>Power Clean 3 x 5</td>
</tr>
<tr>
<td>Quick Squat 3 x 15</td>
<td>Lat Pullover 2 x 15</td>
<td>Push Press 3 x 8</td>
<td>Push Press 3 x 5</td>
</tr>
<tr>
<td>Deadlift 3 x 8</td>
<td>Front Lat. Pulldown 3 x 12</td>
<td>Block Jump 3 x 8</td>
<td>Squat 3 x 10</td>
</tr>
<tr>
<td>Squat 3 x 12</td>
<td>DB Low Row 3 x 15</td>
<td>Tuck Jump 3 x 8</td>
<td>Forward Step Ups 3 x 10 (2)</td>
</tr>
<tr>
<td>Forward Step Up 3 x 10 (2)</td>
<td>DB Shoulder Press 3 x 12</td>
<td>Quic...</td>
<td>DB Bench Press 2 x 12</td>
</tr>
<tr>
<td>Leg Curl 3 x 15</td>
<td>Side Lat. Raise 2 x 15</td>
<td>Leg Curl 3 x 10</td>
<td>Seated Cable Low Row 2 x 12</td>
</tr>
<tr>
<td>Walking Lunge 2 x 10 (2)</td>
<td>Upright Row 3...</td>
<td>Overhead Squat 3 x 12</td>
<td>DB Shoulder Press (SB) 2 x 12</td>
</tr>
<tr>
<td>Standing Calf Raise 3 x 15 (2)</td>
<td>...</td>
<td>...</td>
<td>DB Pullover 2 x 15</td>
</tr>
<tr>
<td>Core Scheme 1</td>
<td>DB Curl 3 x 15 (2)</td>
<td>Alternate Angle...</td>
<td>Straight Arm Lat. Pulldown 2 x 15</td>
</tr>
<tr>
<td>Cardiovascular Scheme 1</td>
<td>DB Triceps 3 x 15 (2)</td>
<td>Standing Calf...</td>
<td>Side Lat. Raise 2 x 15</td>
</tr>
<tr>
<td>Flexibility Scheme 1</td>
<td>Core Scheme 2</td>
<td>Core Scheme 1</td>
<td>Core Scheme 1</td>
</tr>
<tr>
<td></td>
<td>Cardiovascular Scheme 2</td>
<td>Cardiovascular Scheme 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexibility Scheme 1</td>
<td>Flexibility Scheme 1</td>
<td></td>
</tr>
</tbody>
</table>

### Cardiovascular Scheme

- DB Triceps Kickbacks 3 x 15 (2)  
- Standing Calf Raise 3 x 10  
- Side Lat. Raise 2 x 15  
- Core Scheme 1  
- Cardiovascular Scheme 1  
- Flexibility Scheme 1

### Flexibility Scheme

- Core Scheme 1  
- Cardiovascular Scheme 1  
- Flexibility Scheme 1

### Flexibility Scheme

- Core Scheme 1  
- Cardiovascular Scheme 3  
- Flexibility Scheme 1
## Flexibility Schemes

Post Activity Static Stretch (20-30 s x 2 each)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Shoulder X-body</td>
</tr>
<tr>
<td>2.</td>
<td>Shoulder Overhead</td>
</tr>
<tr>
<td>3.</td>
<td>Shoulder Behind – Bent Over</td>
</tr>
<tr>
<td>4.</td>
<td>Hamstrings Standing</td>
</tr>
<tr>
<td>5.</td>
<td>Lower Back Lying (Leg Over)</td>
</tr>
<tr>
<td>6.</td>
<td>Butterfly Lower Back / Groin</td>
</tr>
<tr>
<td>7.</td>
<td>Hamstrings Sitting – Modified Hurdler</td>
</tr>
<tr>
<td>8.</td>
<td>Calves – Push-up Position</td>
</tr>
<tr>
<td>9.</td>
<td>Free Stretch</td>
</tr>
<tr>
<td>Core Workout Schemes</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Scheme 1</strong></td>
<td><strong>Track A</strong></td>
</tr>
<tr>
<td>Crunch (SB)</td>
<td>3 x 12</td>
</tr>
<tr>
<td>Bicycle 3 x 10 (2)</td>
<td>3 x 10 (2)</td>
</tr>
<tr>
<td>Good Mornings</td>
<td>3 x 15</td>
</tr>
<tr>
<td>Lower Back Extensions</td>
<td>3 x 10</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Cardiovascular Workout Schemes

<table>
<thead>
<tr>
<th>Scheme 1</th>
<th>Scheme 2</th>
<th>Scheme 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pick 2 from each category: Ground Based Plyometrics (2), Sprints (2), Agilities (2)</td>
<td>Treadmill, Stationary Bike, Elliptical or Stairmaster</td>
<td>Run 1 mile (fast pace)</td>
</tr>
<tr>
<td><strong>Track A:</strong> 20 min @ 70% MHR</td>
<td><strong>Track B:</strong> 30 min @ 75% MHR</td>
<td></td>
</tr>
</tbody>
</table>

### Ground Based Plyometrics

- A Walks
- A Skips
- Forward Bound
- Lateral Shuffle
- Lateral Bound
- Jump Rope Routine
- Line Hops

### Sprints

- 5 x Shuttle Run (5yd/10yd/5yd)
- 4 x 220 yd (<35s each, 30s rest)
- 6 x 50 yd (<8s each, 15s rest)
- 8 x 25 yd (<5s each, 10s rest)

### Agilities

- 4 Corners (30’)
- Ladder Drills (18”x18” boxes)
- Dot Drill (5 dots in an ‘X)
- Diagonal Shuffle Drill (15’)

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