Design and Implementation of a Specific Strength Program for Badminton

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SUMMARY

BADMINTON IS AN EXPLOSIVE SPORT WHEREBY PERFORMANCE CAN BE ENHANCED FROM RESISTANCE TRAINING. EFFECTIVE RESISTANCE TRAINING PROGRAMMING REQUIRES A SYSTEMATIC PROCESS OF ANALYSIS, IMPLEMENTATION AND EVALUATION TO ENSURE MAXIMUM ADAPTATION AND IMPROVEMENT. THIS ARTICLE FOCUSES ON THE PRESCRIPTION OF RESISTANCE TRAINING METHODS TARGETED FOR BADMINTON SPECIFIC PERFORMANCE ENHANCEMENT AND THE IMPLEMENTATION OF BADMINTON SPECIFIC EXERCISES INTO A PRE COMPETITION OR COMPETITION PHASE OF A PERIODIZED PLAN.

INTRODUCTION

Badminton is an explosive sport that requires the athlete to be able to move in multiple directions while smashing and receiving a shuttlecock with speeds of up to 332 km·h^{-1} (1). Jump smashes, lunges, fast changes of direction; all require the entire body to generate maximum power. Through observation, strength training is used by the majority of elite athletes as a method to enhance on court athleticism. The science of strength training has advanced considerably in recent years with an abundance of research supporting its efficacy. It is important to apply scientifically sound training methods in a systematic manner to ensure that athletes are receiving the best training methods to optimize their sport performance. This article focuses on resistance training methods targeted for badminton specific performance enhancement and the implementation of badminton specific exercises into a pre competition or competition phase of a periodized plan. The program has resulted from many years of refinement of the conditioning program for elite and subelite badminton players of the Malaysian national squads.

A process of analysis, implementation and evaluation (5) will be used to illustrate a resistance training program for badminton. Physical conditioning programs must be guided by a systematic process that continually provides feedback to ensure that the greatest potential for adaptation and improvement is realized.

ANALYSIS

Prior to the resistance training prescription we first analyzed the key movement characteristics of the sport. In particular, muscle contraction profiles in terms of speed, eccentric emphasis, stretch shortening cycle duration and depth, range of motion and body posture were examined to facilitate strength and conditioning program design. This was deduced from observing training/competition, video, reading literature and through discussion with the athletes and coaches. Following is the analysis of several different movements critical to badminton and the appropriate performance characteristics that we highlighted as needing development.

ACCELERATION FROM RECEIVING STANCE TO RETRIEVING A DROP SHOT

The ability to retrieve shots is related to an athlete's tactical skill to read a game and physical ability to accelerate quickly to the shuttlecock. If the athlete possesses the ability to get to the shuttlecock quickly it allows them to a) reach difficult shots; b) execute an effective return shot; and c) conserve energy by executing the shot with comfortable body posture. Reaching the drop shot late will either result in an error or will enable the opponent to easily attack a poorly returned shot. Being late to the drop shot also requires a full stretched deep lunge which is taxing to the body when

KEY WORDS:
power; agility; speed; athlete; periodization

compared to a lunge that does not require full depth. Generally movement to accelerate to the best position uses a small range of motion at the ankle, knees and hips but is very explosive. Athletes will use one of two strategies to accelerate to the shuttlecock.

One method relies on the stretch shortening cycle (SSC) where the player makes an initial dip, or split of the legs (either in sagittal or frontal plane depending on shuttlecock location) before exploding to the ball. The initial dip or split allows a greater ground reaction force to be generated to move more explosively in the intended direction. This type of SSC movement is perhaps best trained with low load, high velocity resistance training methods. Such movements produce high power output by the neuromuscular system and involve dynamic eccentric and concentric actions under a relatively light load (approximately 30% of 1 repetition maximum, (RM) performed as rapidly as possible (9). Examples of exercises we use for this would be the Smith machine single leg split squat (Figure 1) or Smith machine split squat (Figure 2) performed ballistically with a resistance of 30% of 1 RM (of a standard Smith machine split squat). Ballistic training ensures that force is developed throughout the range of motion such as in a standard split squat where the feet do not leave the ground compared to a ballistic split squat where the athlete jumps into the air as high as possible. Ballistic training has been shown to be very effective for the development of muscular power and dynamic athletic performance because it overcomes the problem of the deceleration phase inherent in traditional resistance training and is more specific to the explosive movements found in sport (9).

The explosive nature of ballistic resistance training requires the athlete and coach to be extra vigilant during the preparation and execution of the exercises. In the above examples, the smith machine needs to be of adequate height in order to allow jumping and any boxes that are used must be placed securely to prevent unwanted movement. The bar should be placed high on the shoulders and the trunk should be kept upright throughout the movement. Exercise technique must be carefully scrutinized to ensure that the spine and pelvis are neutral. The ankles, knees and hips must be aligned to prevent any excessive pronation/supination (ankle), adduction/abduction (knee) and internal/external rotation (hip) upon landing and takeoff. To ensure proper frontal plane alignment of the knees and trunk, landings should be balanced with the load distributed evenly between the forefoot and heel of the front leg for the single leg split squat and between both legs for the split squat.

Figure 1. Smith machine single leg split squat. Start with front foot in front of the bar and place toes of the rear leg on a bench or box. Perform a rapid countermovement (to hamstrings parallel) and then explosively jump into the air as high as possible, minimizing the use of the rear leg.

The second method relies more on muscular strength with less involvement of the SSC as the athlete explodes to the shuttlecock without a prior dip or split stance of the legs. This method is often seen when there is limited time to retrieve the shuttlecock and the faster an athlete can move the better chance they have of reaching the difficult shot. The ability to produce high force during predominantly concentric movements has been shown to be a strength quality with good predictive properties and to discriminate well between athletes of different abilities (9). This type of movement requires a rapid rate of force development (RFD) in particular from a relatively relaxed muscle state. RFD is the maximal rate of rise in muscle force and the higher this quality the greater the impulse that will be generated and thus the faster acceleration of the athlete into the desired position (1). RFD can be developed with heavy resistance training (85–100% of 1RM), where the athlete must intend to move the load as rapidly as possible, although actual movement speed will be slow due to the heavy load (11). The goal of this type of training is to improve RFD by increased neuronal drive to the muscle in terms of rate of onset of activation and increased firing frequency. There may also be intramuscular changes in terms of myosin heavy chain isoform composition and sarcoplasmic reticulum release and uptake of calcium (1). Ballistic training with light loads has also been shown to improve RFD, however for badminton and the limited SSC movement in this movement, we have found high force strength training to be more appropriate to overload the muscle in this case. An example of resistance training to improve RFD in badminton would be the staggered stance concentric squat (Figure 3) and wide stance concentric squat (Figure 4).

BODY CONTROL DURING EXECUTION OF A SHOT

Resistance training can also benefit the badminton player to maintain optimal posture and body control when executing shots. Body control is crucial for the execution of an accurate shot. Athletes with poor body control can be seen collapsing at the trunk during front court lunge shots which not only hinders optimal execution of the stroke but also delays the athlete from returning to the ready position in mid court (center of gravity is further forward and away from body when the trunk is collapsed forward). The ability to decelerate is an important factor for body control in the lunge. Deceleration may be even more important than acceleration because it plays a role in changing direction, cutting, stopping, and transitioning from one move or play to another (7). Resistance training exercises we implement to improve body control and deceleration include the 3-phase lunge (Figure 5) and cable lunge decelerations (Figure 6).

Figure 2. Smith machine split squat. Start in a split stance and perform a countermovement (hamstrings approximately parallel) to explosively jump into the air as high as possible. Switch legs after completing the required number of repetitions.

RETURNING TO THE READY POSITION TO RETRIEVE THE OPPONENT'S NEXT SHOT

Some badminton players are slow to return to the ready position after executing shots. This is usually when the athlete is required to be in a deep lunge and happens at all areas of the court. For badminton the ability to quickly complete a lunge and return to the start or move off in another direction is critical for success (3).

Figure 3. Staggered stance concentric squat. After the athlete has mastered parallel concentric squats, progress into a slightly staggered stance. From the low starting position explosively squat as high as possible without any counter movement dip. Spotters are necessary for the eccentric phase.

Figure 4. Wide stance concentric squat. As for normal squatting technique except the stance is wider to mimic the receiving position in match play. Spotters are necessary for the eccentric phase.

Multi direction lunges (Figure 7) performed rapidly are an ideal choice of exercise to use as they work on deceleration, body control and the turnaround phase which is actually a backward or sideways movement as opposed to most forward directed resistance training exercises.

SPECIFICITY IN RESISTANCE TRAINING FOR BADMINTON

It is imperative that precompetition and competition resistance exercises are as specific as possible to bridge the gap between the weight room and on court performance. The use of badminton movements in the form of complex training can be used to achieve this. Complex training generally involves the execution of a resistance training exercise followed relatively quickly by a biomechanically similar plyometric exercise (4). Complex training assumes that the explosive capability of muscle is enhanced after it has been subjected to the prior heavy load. This phenomenon is also known as post activation potentiation (4). Complex training may be as effective if not superior to traditional strength and plyometric training alone for the development of power (6). Some examples of complex training with badminton specific movements include multi direction lunges with lunge return hops (Figure 8) to improve the ability to return to the ready position. A second example is the wide stance concentric squat followed by concentric acceleration movements from the ready position to the front court lunge. This is to simulate and improve acceleration to the front court while minimizing time delaying counter movements. Step up with a plyometric drop back and jump (Figure 9) to simulate and overload the first step of acceleration to the shuttlecock. Squat with jump squat smashes, lunge with smith machine split squat and standing calf raise with ankle hops are other common examples that we use. Researchers have generally found the optimal load for peak power output of the complex exercise (e.g., the jump squat, ankle hop, smith machine split squat) to be in the range of 30–70% of 1RM (8) of the non ballistic version of these exercises. In many instances we use instruments to measure power and use this to guide load selection to the optimal for power output. When such equipment is not available or the movement difficult to measure we start at

Figure 5. 3 Phase lunge. A) From a standing position lunge forward onto the front leg and maintain an upright posture. B) Bend forward at the hips while maintaining a low lunge position. No knee extension or spinal flexion should occur. Range of motion of the exercise should cease if a neutral spine cannot be maintained. C) Return to position A. The only movement is back extension. Finally, return to the starting standing position and repeat for the opposite leg.

Figure 6. Cable lunge decelerations. Stand in a ready position, concentrate and take an exaggerated lunge step. Land and focus on hamstring and gluteus contraction with good posture and knee control.

around 30% 1RM and then progressively increase the weight until the movement speed begins to be dramatically reduced and then ease the load back slightly.

UPPER BODY STRENGTH

The jump smash is the most effective method for scoring point's in badminton. The ability to smash the shuttlecock at high speeds is dependent on skill, however it may also be enhanced with upper body strength and power training. For doubles players in particular strong forearm strength is required for jabbing and pushing. The in-season program will be predominantly designed to maintain upper body strength of the major muscle groups through compound lifts as time is usually limited to train many different exercises for the upper body. The common major exercises for the upper body implemented include bench press (incline, flat), rows (seated, bent over, lat pulldown) and wrist variations (extension, flexion, supination, pronation). Badminton specific exercises include pullovers in a complex with over head medicine ball throws to simulate smashing movements and standing overhead triceps extensions to simulate jabbing.

Figure 7. Multidirectional lunges. Set up cones in a clock pattern at 1, 3, 5, 7, 9 and 11 o'clock. Face 12 o'clock and lunge as fast as possible to all cones, ensuring both feet lunge to every cone.

It must be noted that although this article describes specific resistance training close to or during competition periods, time is allocated for additional exercises that address individual athlete weaknesses or injury prone areas.

SPEED, AGILITY, AND QUICKNESS

We can find no published literature on movement training for badminton. The sport however does require the athlete to be very agile in all directions. We aim to target specific movement training toward the athlete's weaknesses. For badminton players these typically include:

- A poor ability to jump vertically for a smash: This is resolved through a combination of ballistic, strength and plyometric training, depending on whether the athlete has a weakness in the stretch shortening cycle or leg strength. Typical exercises include jump squats, squats, power cleans, double leg hops/bounds and ankle hops.
- A poor ability to move laterally: this can be resolved with plyometric and speed drills that target lateral movement. Exercises include lateral jumps/hops, bungee cord and weighted jacket resisted lateral multi shadows (specific on court lateral direction footwork patterns).
- A poor ability to move backwards to the back court: this can be resolved with drills such as reverse single leg hops and bungee cord and weighted jacket resisted backward multi shadow drills.

From the above analysis it should be evident that there are many different factors which will impact strength and conditioning program design for badminton. Our challenge is always to put it all together for the athlete who is in season and has minimal time available for resistance training. Another major factor to ponder is whether the in season program will focus on maintenance or improvement and this will be dictated by the competition schedule. To address these issues we will now discuss the implementation of the badminton specific exercises into a pre-competition and competition

Figure 8. Lunge return hops. Start in an athletic position and hop forward for a distance of 3 shoe lengths (to start with). Upon landing explosively hop backwards with minimal ground contact time.

program. Before this it must be noted that the following program is based on the elite athlete who has a solid strength training background to such that they are able to tolerate maximal strength loads and ballistic training. The final phase of the analysis phase is the assessment of the individual athlete to determine their relative strengths and weaknesses in power, speed and force development in various movements. This performance analysis is critical to prioritizing goals and establishing starting loads to be used in training. Rather than enter into a detailed discussion of performance diagnosis we refer the interested reader to Newton and Dugan (9).

IMPLEMENTATION

The majority of elite badminton players are professional and focus on earning income and improving world rankings for higher seeding and a more favorable draw at International competition. Traditionalists may disagree with this approach but the reality that strength and conditioning specialists face is that this is a career profession and traditional linear periodization strategies will not be suitable for such athletes. Linear periodization looks to build hypertrophy, then maximum strength followed by power to peak at two to three major tournaments a year. Linear periodization does not work with elite athletes that compete in more than 8 tournaments a year. This is because the athletes feel somewhat "stiff and slow" in a hypertrophy training phase that focuses on high volume and low intensity; athletes feel "heavy" and "stiff" in a maximum strength training phase and only feel light and fast in a power development phase. Therefore physical condition and competition readiness is somewhat sacrificed during the hypertrophy and maximum strength phases. However linear loading and periodization is not completely abandoned, particularly if there is adequate training time without competition, and/or an athlete requires extra emphasis on a single physical parameter (eg., hypertrophy).

Table 1 provides an example of a weekly precompetition training microcycle. Tables 2 and 3 outline a resistance training program that follows a nonlinear loading pattern and addresses the need to be in a competition-ready state. The sample program can be used in the weeks leading up to a major competition.

Day 1 (refer to Table 2) of resistance training combines high load strength training with ballistic movements of the lower body for the purpose of training the force component of power. The Day 2 program (refer to Table 3) focuses on the time component of power by using lighter loads combined with specific and ballistic exercises.

EVALUATION

The next step of the system for physical conditioning programming that we apply is Evaluation. We continually monitored the athletes to assess progression through the season to ensure the program continues to be effective. Frequent assessment will enable any necessary adjustments for the athlete's current physical levels. Simple time effective tests can be used so that the athletes' training is not disrupted. Some easy to administer tests that we implement include predicted 1RM strength tests (from training), isometric squats against an immovable bar with a force platform to measure maximum and rate of force development changes, vertical jump, squat jump and drop jump.

CONCLUSION

Effective resistance training programming requires a systematic process of analysis, implementation and

Figure 9. Plyometric drop back and jump. Start in between 2 cones 1 meter apart, jump backwards approximately two shoe lengths (to start with). Land on one leg and with minimal ground contact time explosively jump forward over either cone (to simulate forehand or backhand movement)

evaluation. The analysis of badminton has determined that there is a variety of strength qualities required for badminton specific performance and a variety of loading strategies can be applied to train these qualities.

Similar programs to those listed have been successfully used with top elite level badminton players that have a good foundation of basic strength and power training. However as with any program a comprehensive individual analysis needs to be done to determine strengths weaknesses and what physical conditioning is required. Resistance training may be less of a priority for the athlete that is already physically strong and fast. Greater training efficiency may be derived from prioritizing other performance qualities such as technical, tactical or mental skills development. In such cases the strong and powerful athlete should not dismiss resistance training but rather vary the intensity and volume of the periodized plan to optimize or maintain physical training adaptations and reduce the risk of sports-related injuries.

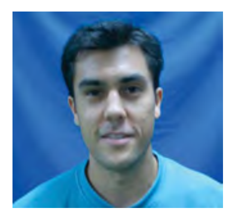

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Table 1
Sample microcycle plan for training in between international tournaments for an elite player building into a major tournament.

	MON	TUES	WEDS	THUR	FRI	SAT	SUN
Morning	Agility/Speed + Technical + Tactical badminton training (T+T)	T + T	Match play	Agility/Speed + T+T	T + T	Match play	Off
Evening	Resistance training	T + T	Off	Resistance training	T + T	Off	Off
Overall Daily Intensity	High	Med-high	Low-med	High	Med-high	Low-med	Low

Table 2
Day 1 Resistance Training -- Power force emphasis

Choice and order of exercise	Sets x Reps	Rest	Load X 1RM	Purpose
Heavy lunge	3 × 6	180s	85%	Stimulation of nervous system for a specific movement for the ballistic jumps
+ Smith machine split squat	3 × 5/leg		30%	Perform ballistically within 60 seconds of the heavy lunge to train the time component of power for specific contraction velocity
Bench press	8, 6, 4	2–3 min	80–90%	Maintain upper body strength
Squat + squat jump	3 × 6	180s b/w sets	85%	Complex jump squats performed 60s after squats
	3 × 10		30%	
Bent over rows	8, 6, 4	2–3 min	80–90%	Maintain upper body strength
Calf raise + ankle hops	3 × 10	120s	10 RM	Explosive ankle extension for all movements
	3 × 10		Bar	

Table 3
Day 2 resistance training -- power-time emphasis

Choice and order of exercise	Sets × Reps	Rest	Load × 1RM	Purpose
Multi direction lunges	3 × 6/leg	120s	5–10kg dumbbells	Multi lunges are light for specific contraction velocity and are multi directional as played in the game.
+ lunge return hops	3 × 5/leg		bodyweight	Plyometric drill for rapid acceleration out of a lunge.
Standing tricep extension	3 × 8	120s	5–10kg dumbbells/EZ bar	Stimulate the muscles involved in jabbing.
+ heavy racquet jabs	3 × 10 seconds		Squash or heavy racquet	Specific jab swings with a racquet.
Staggered/wide stance concentric squat	3 × 6	180s b/w sets	75–85%	Potentiate the muscles involved in various stances used in defense to attack.
+ staggered/wide stance Smith machine jump squat	3 × 10		30%	Performed within 60s of the heavy squat.
+ specific shadowing from athletic stance				Transfer of resistance training exercise to exact badminton movements.
Single arm/single leg dumbbell rows	10,8,6	2 min	10–15kg dumbells	Maintain upper body strength, postural control and single leg balance
Calf raise	3 × 10	120s	10 RM	Explosive ankle extension for all movements.
+ ankle hops	3 × 10		Bar	

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