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Supplemental Exercises for Core Stability Which Utilize the Concept of Parametric Oscillation in the Hammer Throw

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ABSTRACT

TRAINING FOR THE HAMMER THROW HAS TRADITIONALLY BEEN SEPARATED INTO 2 PARTS. THE PRIMARY TRAINING METHOD IS THROWING OF THE HAMMER, WHEREAS THE SECONDARY/SUPPLEMENTARY METHOD INVOLVES VARIOUS STRENGTH AND CONDITIONING EXERCISES TO IMPROVE THE ATHLETE'S FITNESS LEVELS FOR THROWING PERFORMANCE. THE IMPLEMENTATION OF SPECIAL STABILITY EXERCISES IN THE WEIGHT ROOM THAT USE THE PRINCIPLE OF PARAMETRIC OSCILLATION FOUND IN THE HAMMER THROW MAY BE AN EFFECTIVE WAY TO ENHANCE STABILIZATION SKILLS THAT MAY POTENTIALLY OPTIMIZE HAMMER THROWING PERFORMANCE. THESE ADVANCED MIDSECTION EXERCISES ALSO MIGHT PLAY A ROLE IN INJURY PREVENTION. FOR A VIDEO ABSTRACT OF THIS ARTICLE SEE SUPPLEMENTAL DIGITAL CONTENT 1 (SEE VIDEO, HTTP://LINKS.LWW.COM/SCJ/A206).

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INTRODUCTION

The hammer throw is a track and field event in which a hammer weighing 7.26 kg and 121.5 cm (4 feet) in length for men, or 4 kg and 119.5 cm for women is thrown as far as possible. This is done by generating both rotational and translational movements to increase the speed of the "hammer head" up to the point of final release, while staying within a throwing circle that is 7 feet in diameter (Figure 1A–E). The throwing movement can be divided into 3 stages, the preliminary winds (Figure 1A), the turns (3 or 4) (Figure 1B), and the delivery (Figure 1E). During the final release, the tension of the hammer wire can go up to 350 kg (700 lbs) and the hammer head can attain a speed of over 29.0 m/s (65 mph) in an 80 m (262 feet) throw (13,16). These dynamics enable the hammer-throwing athlete to produce the highest kinetic energy of any sport (19).

The unique nature of how the hammer is thrown makes it unlike any other throwing event in the world of track & field. Other throwing events (javelin, shot put, and discus) use an acceleration pattern with a pronounced acceleration of the

KEY WORDS:
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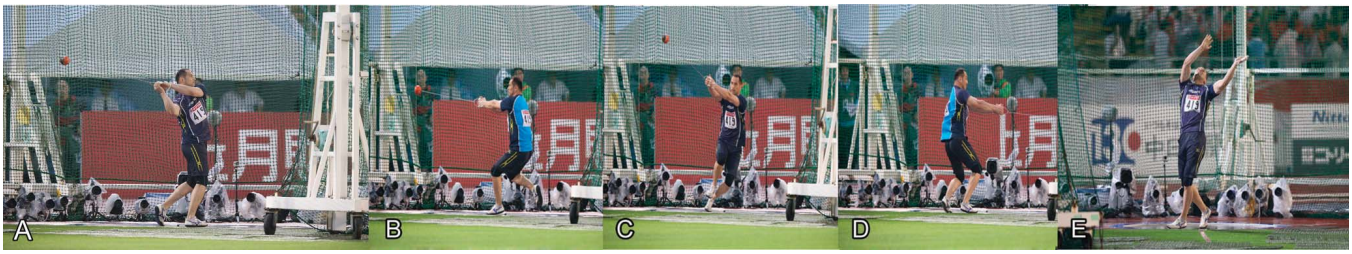

Figure 1. The hammer throw.

implement in the delivery phase (2,11,15). In the case of these 3 disciplines, the throwing of the implement is done with 1 arm, and the vast majority of the final release velocity (70–85%) is generated at the very end of the throwing movement (9). Contrary to this, most implement velocity in the hammer throw is built up at the beginning of the throw in the winds, and then proceeds to follow an undulating pattern of accelerations and decelerations in which the hammer head gains the remainder of it's final release speed over a much longer path measuring 60–70 m (3,4,12). Along this course, the hammer head's movement will follow an angled elliptical path or "orbit" around the thrower as they complete 3 to 4 turns before release (Figure 1A–E). The hammer head accelerates as it moves downward toward the low point of the orbit, whereas it decelerates as it moves upward toward the high point in each of these turns (Figure 2). Throughout the course of the turns, the acceleration portion of the hammer's path uses the principle of parametric oscillation (Figure 3) to allow the hammer head to develop a high level of kinetic energy before it's release (20).

Another distinguishing feature of this sport is that the hammer head is connected to the thrower by a wire and handle grip and is not directly in contact with the thrower's hand. This is the most important feature that differentiates it from the other throwing disciplines (shot put, discus, javelin) (Figure 5). Because of this configuration, a small amount of torque is applied between the handle and the thrower's hand. As the thrower exerts force on the hammer handle in the acceleration phase, it will cause the handle to initially rotate around the axis of rotation at a slightly faster rate than the hammer head (20). This will cause the hammer head to briefly lag behind the handle (Figure 4), only to swing through and catch up with the handle as it moves through the low point of the orbit (20). The lag will cause the local maximal force to be acting on the hammer around the low point, where the hammer will feel it's "heaviest" (20). The following tugging (or "pulling") movement at the low point causes the optimal acceleration method to be parametric oscillation, which is typically seen in swing movements based on the double pendulum effect (18). The acting force caused by the double pendulum may make it difficult for the hammer thrower to achieve an asynchronous vertical movement between the hammer head and the thrower's center of gravity (CG) which is needed for acceleration of the implement (17). Therefore, it is inferred that hammer throwers who can better manage the timing of the delayed movement of the wire and hammer head will be more skilled at aligning their

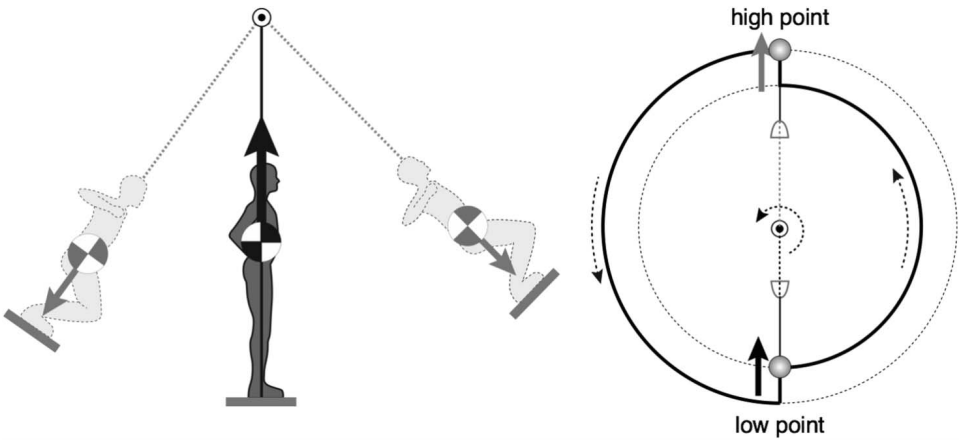

Figure 2. Parametric oscillation.

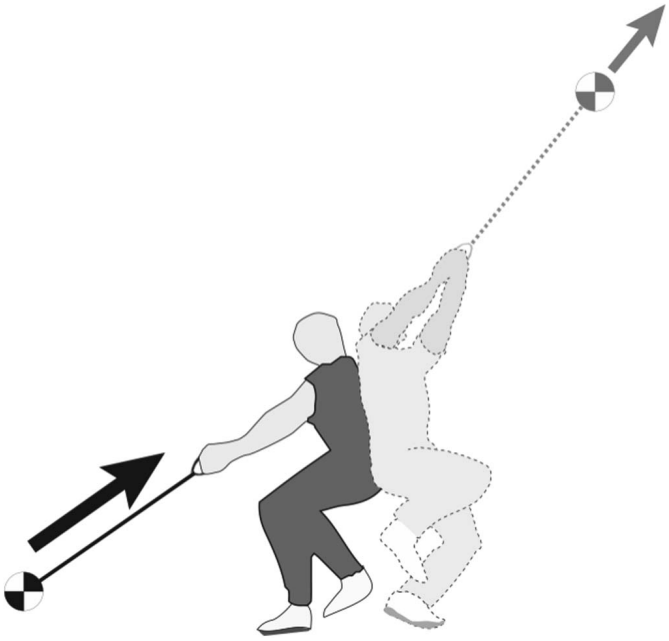

Figure 3. Low and high point during hammer throw.

asynchronous vertical movement of CG and the hammer head, which may lead to optimal hammer head acceleration (17).

Refinement of these skills may enable the hammer throwers to enhance their peak levels of throwing performance. It is believed that a comprehensive training program that combines both low- and high-intensity exercises in a variety of movements can increase sports performance (7). It is for a combination of these reasons that the idea of creating strength and conditioning exercises for the hammer throw that use the concept of the parametric oscillation seen within the movement of the throw was born. The insertion of these specialized exercises into a well-rounded training program can allow the thrower to work on holding and timing various hammer-like movements and positions, while responding to an ever-changing stimulus. Proficiency in these types of sport-specific exercises could potentially translate into more efficient movements in the hammer ring (8,19). We have given this distinct group of exercises the name "hammerobics."

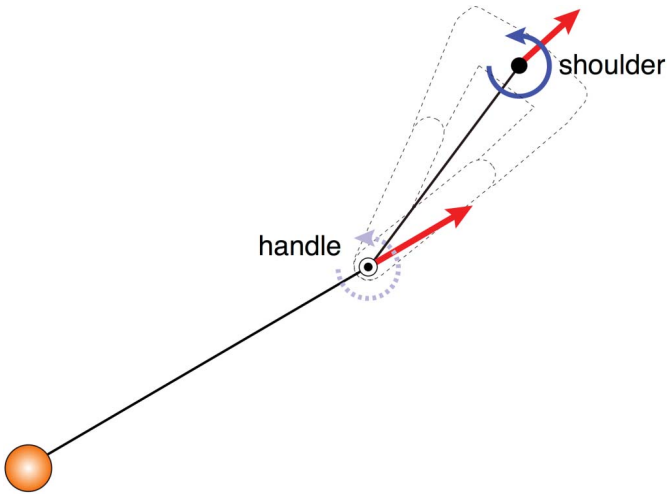

Figure 4. The hammer head lags behind the handle.

DEVELOPMENT OF EXERCISES

The complex nature of the hammer throwing movement allows for a wide variety of training methods to be used within the field of strength and conditioning to benefit performance (1). As similar to most throwing disciplines, Olympic-style lifts, such as the snatch and clean, tend to make up the main exercises for hammer throwing strength and conditioning programs, along with a wide assortment of squat variations (10). These types of exercises, while effective, can be very repetitive and involve the same motion repeated over and over from season to season. With the same training replicated over a number of years, there may be an increased likelihood for an overuse injury to develop (14).

Hammerobics exercises may offer a different way to train the body while avoiding the repetitive nature of classic weight training exercises because of the ever-changing stimulus provided by the oscillating weights. For this reason, the addition of hammerobics exercises into an athlete's program can add variety and may help decrease this possibility of overuse injury, while also developing the athlete's ability to move and feel resistance that changes in an asymmetric and unpredictable manner. These special exercises may also enhance the thrower's stability-strength in sport-similar body positions, and may additionally enhance relevant motor skills related to fine adjustments to complex movements with an ever-changing stimulus. This, in turn, may translate into more efficient movements in the hammer ring, resulting in more optimal force production during the throw (17).

DESCRIPTION OF EXERCISES

The basic set-up for hammerobics exercises involve a hammer that is attached using looping the wire to each end of a bar (Figure 6). This will allow

Figure 5. Wire and handle grip which connect the hammer with the thrower's hand.

for traditional weight lifting variations to be performed as the hammers swing back and forth to provide a constantly changing stimulus pattern while the athlete is performing the exercises through the standard range of motion.

Figure 6. The basic set-up for hammerobics exercises with a hammer attached by looping the wire to each end of a bar.

To start each exercise that begins out of a rack (stability squat, bench press, and step up), the lifter will set the weight in motion by pushing them in the desired direction and intensity before they begin the lift. A second lifter or "spotter" can also be the one to initiate the swinging of the hammers if the lifter is not comfortable doing this on their own. For exercises that start from the floor (such as the deadlift), the hammers connected using wire will be laying out horizontally, in the appropriate direction, before the bar is lifted from the ground. As the bar is lifted from the ground, the weights will swing into motion to provide the desired stimulus.

It cannot be emphasized enough that the primary goal of performing hammerobics exercises is to maintain proper form and rhythm while completing the exercises. The focus should not be to see how much amplitude can be put on the swinging of the hammers. Furthermore, there should not be an emphasis on "pushing the weight" to see how much one can lift with these types of exercises, for it can increase the likelihood of injury (5,24). The primary focus should be on mastering the movement, just as one tries to master the top-level hammer technique.

The stability squat can be performed as a traditional back or front squat, either isometrically, or at an even lifting cadence, while two 16 lb/7.26 kg hammers hang from the bar (Figure 7A–C, see Video, Supplemental Digital Content 2, http://links.lww.com/SCJ/A207). Variations of this squat can be performed by putting the hammers in motion to oscillate in similar directions (Figure 8B, see Video, Supplemental Digital Content 3, http://links.lww.com/SCJ/A208), or to oscillate back and forth on the ends of the bar in opposite directions (Figure 8A, see Video, Supplemental Digital Content 4, http://links.lww.com/SCJ/A209). Rhythm and tempo must be maintained during the repetitions, which will ensure that the oscillating resistance will

Figure 7. Stability squat.

provide an ever-changing stimulus to which the athlete must continually adjust. The amplitude of the oscillating hammers should not surpass 90° relative to the vertical plane.

During the course of the exercise, the primary challenge for the lifter will be to maintain the oscillating movement of the hammers, while either holding an isometric squat or moving through a complete range of squatting motion. Lifters initiate the exercise by shifting their center of gravity back and forth, between the heels and toes of both feet, as they begin the squatting exercise, while the hammers are swinging in the same direction. Then, the lifter will transition to a small pumping up and down motion of the legs to keep the hammers swinging. For exercises in which the hammers are swinging in opposition, athletes will perform similar shifting and pumping actions; however, the movements will be coordinated

Figure 8. Stability squat with oscillations.

Figure 9. Calf raise with oscillations.

between the opposing heels and toes as they execute the exercise.

As with most hammerobics exercises, it is recommended to begin with the easiest variation, in which the hammers are swinging in the same direction. Simultaneous swinging allows athletes to have an easier time of keeping the hammers in motion because both legs will work the same way as they go through the squatting motion. They can then advance to squatting with the hammers swinging in opposing directions. This is a more complicated task since each leg will have to move independently and in opposing directions, to keep the hammers moving in opposing directions. This concept may translate over to the hammer throw because both legs will work independently through the course of the throw using a heel-toe alignment to execute the turns. The emphasis on coordinated individual leg movement patterns may also be important because over 50% of the turning motion in the hammer throw occurs while only one leg touches the ground (6).

The depth of execution in the squat is also important. The lifter should start with an easier variation, such as

Figure 10. Isometric deadlift.

Figure 11. Good morning with oscillations.

a partial or quarter squat (Figure 7B), and gradually work down toward a squatting position similar to that found in the execution of the actual throw, as they become more skilled at the exercise (Figure 7C). The ultimate goal of the stability squat is to execute at a depth that is similar to that found in the actual throw. Performance of the exercise in a way that closely resembles the throwing technique may allow for a greater transfer of training for this particular exercise (8,19).

Calf raise exercises can also be performed with a similar rhythm and tempo as the stability squat while the athlete maintains the swinging motion of 2 hammers moving in either opposing or similar directions (Figure 9, see Video, Supplemental Digital Content 5, http://links.lww.com/SCJ/A210). As with the stability squat, it is recommended that the lifter should start out with the hammers swinging in unison and only advance on to the variation with hammers in opposing motion when they are comfortable and can master the movement properly.

The isometric deadlift exercise has 2 variations. Because this exercise begins with the lifter pulling the weight off the floor, the connected hammers will be laid out horizontally on either side of the bar (for hammer oscillation in opposition) or on the same side of the bar (for hammer oscillation in unison). In both variations, the lifter will begin by pulling the weight from the floor into their holding position to set the hammers in motion. The deadlift is typically performed from a hanging position with the knees bent at a 45° angle and the feet placed slightly wider than shoulder width apart (Figure 10A). The lifter will gently move the bar with the arms and upper body to start the motion, so that the hammers will maintain their swinging motion either in unison (Figure 10A, see Video, Supplemental Digital Content 6, http://links.lww.com/SCJ/A211) or in opposing directions (Figure 10B, see Video, Supplemental Digital Content 7, http://links.lww.com/SCJ/A212). Once the hammers are in motion and their position is set, the lifters will be able to maintain the swinging using mainly their feet, hips, and lower body, while keeping

Figure 12. The "oar" exercise.

Figure 13. Kettlebell swing.

the upper body stable. If done correctly, only a small lower-body movement will be needed to maintain a big swing in the hammers by manipulating and timing their momentum. Poor technique, in which the lifter has a large upper-body movement and tense arms, will cause a smaller oscillation of the hammers. These technical points are similar for the stability squat exercise.

The "oar" is a posture-driven exercise that is very specific to the hammer throw. It is considered the most advanced of the hammerobics exercises and is usually only used by advanced athletes/throwers who have personal bests at or over 60 m. The body position that is assumed to execute this exercise is very similar to that which the hammer thrower maintains during an actual throwing movement (Figure 12A, see Video, Supplemental Digital Content 8, http://links.lww.com/SCJ/A213). The lifter will maintain a rigid semisplit squat position, with outstretched arms, while holding the end of a bar that is anchored into the corner of a wall or lifting platform. In the advanced version of this exercise, a 7.26-kg hammer that is attached to a lifting bar, will be triggered to swing back and forth like a pendulum by the lifter as they gently move their body and lifting bar back and forth while maintaining their strict body posture. An easier version of this exercise can be used by either adjusting the hold on the bar so that it is much closer to the lifter's center of mass, just above the hips (Figure 12B, see Video, Supplemental Digital Content 9, http://links.lww.com/SCJ/A214) or by adding more weights to the bar very close to where the lifter grips.

The kettlebell swing is another posture-driven exercise in which the lifter holds

Table 1
Suggested weights and repetitions for hammerobics exercises

Name of exercise	Weight for men	Weight for women	Repetitions and sets	Rest between sets
Stability Front or Back Squat	50–100 kg/16 lbs × 2	30–60 kg/4 kg × 2	10–20 sec × 3	3–4 min
Calf Raise	20–50 kg/16 lbs × 2	15–30 kg/4 kg × 2	10–20 rep × 3	2 ½–3 min
Kettle Bell Swing	6–20 kg	4–10 kg	10–20 rep × 3	3–4 min
Oar-straight arm/bar 20 kg for male; 15 kg for female	0–5 kg/16 lbs × 1	0–4 kg × 2 arms can be bent	10–20 rep × 3	3–4 min
Deadlift	50–100 kg/16 lbs × 2	20–50 kg/4 kg × 2	10–20 sec × 3	3–4 min
Good Mornings/bar 20 kg for male; 15 kg for female	20–40 kg/16 lbs × 2	15–20 kg/4 kg × 2	10–15 sec × 3	3–4 min

Table 2
Suggested training progression for hammerobics exercises in general preparation phase

	Sessions per week	Exercises per session
Developing Athlete (<60 m)		
General Preparation Phase	2–3	2–3[a]
Pre-Competition Phase	2	1–2[a]
Competition Phase	1–2	1–2 with light weight[b]
Advanced Athlete (>60 m)		
General Preparation Phase	2–3	2–3[b]
Pre-Competition Phase	2–3	1–2[b]
Competition Phase	2	2 with light weight[b]

[a]Placed at beginning of session.

[b]Placed at end of session.

a kettlebell behind their head as it dangles from a four-foot rope or band (Figure 13A, see Video, Supplemental Digital Content 10, http://links.lww.com/SCJ/A215). Unlike other hammerobics exercises that have been introduced so far, the lifter will directly hold the oscillating resistance in their hand. While holding their base posture, with feet slightly wider than shoulder width apart, the lifter will start by rhythmically moving their body from right to left so that the kettlebell will swing from side to side like a pendulum. As the amplitude of the kettlebell's motion increases, the lifter will gradually reduce the amount of body movement as long as they counter balance the kettlebell's movement. This will be done with enough intensity to swing through a range of motion up to 180°, while still maintaining an upright posture (Figure 13B). Ideal technique for this exercise will see the lifter minimizing their movement while being able to maximize the movement of the kettlebell within the recommended parameters. The suggested introductory weight of the kettlebells can range between 4 and 6 kg. Careful attention should be paid to the lifter's ability to maintain posture during the execution of these exercises, and weights should be decreased if proper form cannot be maintained. It is also recommended that a modest progression be pursued as the lifter becomes more proficient. Suggested repetitions for this exercise can vary between 10 and 20 reps in each direction.

PRACTICAL APPLICATIONS AND CONCLUSION

Hammerobics exercises are characteristically introduced into the training

Table 3
Sample training week general preparation phase

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Throws	*Throws*	REST	*Throws*	*Throws*	REST	*Throws*
Variety of hammer drills	Variety of hammer drills		Variety of hammer drills	Variety of hammer drills		Variety of hammer drills
Throws	Throws		Throws	Throws		Throws
At Gym	*At Gym*		*At Gym*	*At Gym*		*At Gym*
Clean 3 × 5, 7 × 3	Snatch 3 × 5, 7 × 3		Clean 3 × 5, 7 × 3, 2 × 2, 1 × 1	Snatch 2 × 5, 6 × 3		Snatch 3 × 5, 4 × 3
Hammerobics	*Hammerobics*		*Hammerobics*	*Hammerobics*		*Hammerobics*
SQ 7 × 5 (hang 9 kg × 2 hammer)	Front-SQ 7 × 5 (hang 9 kg × 2 hammer)		SQ 7 × 5 (9 kg × 2 hammer)	Front-SQ 7 × 5 (hang 9 kg × 2 hammer)		SQ 7 × 5 (hang 9 kg × 2 hammer)
Twists 5 × 10	Swing-back 3 × 18 1 amplitude = 1 rep		Deadlifts 5 × 15 s (9 kg × 2 hammer)			Calf raises 3 × 15 (hang 9kg × 2 hammer)
			Twists 5 × 10			

program at the beginning of the general preparation period. Within the general preparation period, hammerobics exercises can be performed 2 to 3 times a week with 2 to 3 exercises performed per session. Hammerobics days are usually separated by 48–72 hours to allow for recovery between sessions. It is recommended that the passive rest period between sets can range between 3 to 4 minutes based on the athlete's fitness or performance level (Table 1) (22). Table 1 also provides a brief summary of the suggested weights and repetition schemes in each for the most common hammerobics exercises. The insertion of these exercises at the initiation of the general preparation phase may help in the development of good stability strength before progressing on to more dynamic classical exercises such as snatch or power clean, which require a sufficient level of core stability to perform properly (23).

Hammerobics exercises can be kept in the program to varying degrees during the whole training year. Typically, a modest tapering down to 2 hammerobics sessions per week occurs in the precompetition period, and only one to 2 exercises per session. Further tapering can occur in the competition period down to one to 2 sessions per week and 1 to 2 exercises per session with lighter weights. Hammerobics exercises can be placed in the beginning of the training session during early season training in the general preparation period. As fitness and execution of the exercises improve, they can be relocated to the end of the program since these exercises are supplementary in nature, relative to classical weight lifting, and may also serve as a cool down (21). Table 2 provides a more detailed example of how a developing athlete may format hammerobics exercises into the various phases on their training program. Table 3 provides an example of how hammerobics exercises can be incorporated in the general preparation training phase.

Other hammerobics variations can be derived from main stream weightlifting exercises, such as the good morning (Figure 11), lunge, step up, and bench press. These types of exercises can not only be used for the hammer thrower's training and supplementation, but may be beneficial in the general training for a variety of other sports such as baseball, volleyball, golf, wrestling, rugby, American football, and other throwing events in track and field. Further modifications can happen by shortening the length of oscillating weight to add variation to the stimulus. In the case of the bench press, a shorter wire may offer the added benefit of decreasing the possibility of injury because it will prevent the weight from potentially hitting the lifter if it were to get out of orbit.

To conclude, the use of hammerobics exercises offers a new approach to train the athlete's stability strength by using the principle of parametric oscillation to enhance relevant motor skills toward the goal of optimizing hammer throw technique. Although initially designed for hammer throwers, the positive training effects may carry to other sports that use twisting and slinging motions. While there is no intention to suggest that these exercises could replace the benefits of classical weight lifting, it is conjectured that hammerobics exercises may be considered supplemental exercises that can be combined with classical weight lifting as a strategy to diminish the negative effects of repetitive training over a number of years. This may be a very beneficial approach for older or masters athletes in power sports who are searching for ways to maintain performance and stay healthy. Further research and investigation is needed in the form of force plate and EMG studies to quantify the exact mechanism of benefits derived from these exercises. The next step in this course of study will be the mathematical modeling and measurement of the hammerobics exercises to clarify how to adjust the load and make it the most effective.

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