BACKGROUND

I AM A BIOMECHANIST FOR A MAJOR PROFESSIONAL SPORTS ORGANIZATION. IN THAT ROLE, I ANALYZE BIOMECHANICAL DATA TO IMPROVE PLAYER PERFORMANCE.

I was retained to conduct a full 3D biomechanical analysis of Flyweight using the BTS Bioengineering Sportlab. A selection of exercises using a 225lb barbell were compared to a selection of exercises using the 10lb Flyweight. The analysis involved 3D motion capture cameras, force plates, and EMG, at the Nicholas Institute for Sports Medicine and Athletic Trauma (NISMAT) at Lenox Hill Hospital in New York City. This type of system is the gold standard for biomechanical analysis and is used in research hospitals and universities around the world. Using the BTS Sportlab, the precise movement of the athlete and Flyweight were recorded in 3D.

SUMMARY OF FINDINGS

IT IS MY OPINION THAT FLYWEIGHT ENABLES A UNIQUE FORM OF RESISTANCE TRAINING THAT CAN BENEFIT ATHLETIC PERFORMANCE IN WAYS THAT OTHER FORMS OF RESISTANCE TRAINING DO NOT.

The distinguishing characteristic of Flyweight is its configurable shape. Like a baseball bat, golf club, barbell or any other load that is put in motion, the shape and the distribution of the load influences the magnitude of and velocity at which an athlete can apply force.

Flyweight allows the athlete to manipulate the shape and weight distribution of the load. From a biomechanical perspective, this allows the athlete to alter the resistance on the body while freely accelerating and actively decelerating the Flyweight at high speeds. Importantly, through ranges of motion that mimic the biomechanics of explosive athletic movement patterns.

The data collected show that through such acceleration and active braking, the mechanical resistance of Flyweight resulted in the athlete producing high levels of concentric and eccentric forces at substantially higher speeds than traditional barbell movements. Resultantly, Flyweight movements at a weight of ten pounds were demonstrated to at times allow the athlete to generate greater Power output and higher levels of muscle activation than in traditional barbell movements at the substantially greater weight of 225 lbs.

The Flyweight movements also outperformed the traditional medicine ball by wide margins, further suggesting that the Flyweight approach to external resistance yields unique benefits, even when compared to traditional ballistic movements.

The greater outputs of the Flyweight movements can be attributed to the active braking of Flyweight that is absent from the ballistic movement of the medicine ball. This type of bimodal training (accelerate and brake) is key to explosive athletic function, and the data show that Flyweight uniquely enables it The Flyweight movements were also shown to generate high levels of muscle activation and greater work done, which is indicative of a higher metabolic value (i.e., greater calorie burn). The data therefore suggest that Flyweight can also be highly efficient in effectuating changes in an athlete's body composition.

Based on the study, it is my conclusion that the Flyweight approach to external resistance is uniquely effective. It bridges a mismatch between the lower speeds at which force is often produced inside the weight room and the higher speeds at which force must be produced in explosive athletic movements.

DISCUSSION

The results of the study can be explained by the underlying biomechanical principals at work, which are often overlooked, yet fundamental. They are:

Force = Mass x Acceleration.

Power= Force x Velocity

And so, mass/weight ("Load") alone does not define either force or power.

As seen in a sprinter, a boxer and the swinging movements of a golfer or baseball player, it is the speed at which the athlete puts a load in motion that defines these explosive athletic functions, not strength as defined by one-repetition of maximum load.

The Force-Velocity Curve explains how fast an athlete can move while producing a given amount of force. The relationship between speed and force is inverse: as force increases, speed must decrease; or as speed increases, maximum force must decrease.

Research has shown that training at high speeds causes a faster rate of firing of the motor units in muscles to generate that speed[1]. Training the fast twitch fibers in muscles is key for creating explosiveness and force production at high velocities in an athlete.

If an athlete trains at slow speeds, this will increase their maximum force output at low speeds, but not necessarily their force output at high speeds[2].

Flyweight is designed for training in the high-speed portion of the Force-Velocity Curve, allowing the athlete to accelerate to high speeds and train to increase their force and power output at those high speeds. This is shown by the data, where the Flyweight is moved at substantially higher speeds than the barbell.

THE BENEFITS OF FLYWEIGHT

The data show that the Flyweight approach of focusing on power output at high speeds yields substantial benefits relevant to athletic function. The 225lb Barbell produced higher peak force (Power Clean). However, the Flyweight movements produced the highest (a) peak power (Flyweight Throw), (b) peak velocity (Flyweight Slam) and (c) work done (Flyweight Slam).

PEAK MEASUREMENTS

Data	Unit	Flyweight Slam	Flyweight Chop	Flyweight Punch	Flyweight Throw	Flyweight Pull	Bench Press	Clean & Jerk	Med Ball Slam	Power Clean
Output										
Peak Velocity	MPH	21.8	13.7	15.2	17.9		1.5	4.8	17.8	5.2
Concentric Force	N	234	327	244	469		1,675	1,987	479	2,335
Eccentric Force	N	502	387	502	594		1,098	867	-	1,348
Power	kW	4.10	1.99	2.01	4.43		0.80	3.31	2.80	4.04
Work Over 30 s	kJ	26.0	12.3	13.2	15.0		11.9	17.4	11.4	20.8
Muscle Activation										
Gluteus maximus	mV	1.11	0.36	0.31	0.23	0.36	0.25	0.51	0.15	0.49
Latissimus Dorsi	mV	0.37	0.45	0.19	0.11	0.22	0.11	0.71	0.40	0.75
Obliquus externus abdominis	mV	0.89	0.64	0.54	0.57	0.26	0.12	0.26	0.40	0.28
Rectus abdominis	mV	0.78	0.58	0.47	0.40	0.37	0.25		0.24	
Rectus femoris	mV	0.32	0.44	0.37	0.32	0.40	0.09		0.20	

[1] Harwood B, Choi I, Rice CL. Reduced motor unit discharge rates of maximal velocity dynamic contractions in response to a submaximal dynamic fatigue protocol. J Appl Physiol (1985). 2012 Dec 15;113(12):1821-30. doi: 10.1152/japplphysiol.00879.2012. Epub 2012 Oct 18. PMID: 23085960.

[2] Janusevicius D, Snieckus A, Skurvydas A, Silinskas V, Trinkunas E, Cadefau JA, Kamandulis S. Effects of High Velocity Elastic Band versus Heavy Resistance Training on Hamstring Strength, Activation, and Sprint Running Performance. J Sports Sci Med. 2017 Jun 1;16(2):239-246. PMID: 28630577; PMCID: PMC5465986.

PEAK POWER GENERATION

The primary goal in sports is to move at the highest speeds, whether it is the athlete's hand in pitching, the club in golf, or the body in running. In order to achieve these high speeds, the body must produce the highest forces possible at the highest speeds possible.

Peak power allows this combination of speed and force to be measured. The higher the power the greater the athletic potential.

The highest peak power output was seen in the Flyweight throw. Notably, the Flyweight slam produced the second highest peak power output.

TOTAL WORK DONE (POWER OUTPUT EACH SECOND)

The work done during an exercise is a significant factor in how many calories are burned during a workout. Age, weight, sex, and other factors contribute as well, but total work done is generally the best indicator within an athlete.

The highest work output was seen in the Flyweight Slam, which produced: (i) 129% more Work Done than the medicine ball slam, and (ii) 49% more Work Done than the 225 lb barbell Clean and Jerk.

MUSCLE ACTIVATION

Electromyography (EMG) systems allow researchers to see when muscles are firing and how much they are firing. EMG sensors were placed on many of the major lower body and core muscles during the Flyweight and traditional exercises to evaluate the differences in muscle activity.

The 10lb Flyweight movements produced the highest muscle activation in every muscle group tested except for the lats (225 lb power clean). Specifically, the Flyweight movements produced highest muscle activation in the glutes (Flyweight Slam), quads (Flyweight Chop), Rectus abdominis (Flyweight Slam) and obliques (Flyweight Slam).

PEAK FORCE

The highest peak force output was seen in the 225lb Barbell Clean.

Notably, however, peak force was often seen in the eccentric phase with Flyweight movements, at high velocity. Comparatively, in the barbell movements, the eccentric phase produced sub-maximal force, at significantly lower speeds.

The peak eccentric force output seen in the Flyweight is significant because research has shown that during eccentric training, fast twitch motor units are recruited before slow twitch motor units. In addition, greater muscle hypertrophy and larger force production are seen after eccentric training[3].

A recent idea in professional sports is that an athlete's ability to generate concentric force and accelerate is limited by the amount of force which an athlete can generate in the eccentric phase to stop the movement. If an athlete doesn't have the ability to decelerate sufficiently, the body won't allow itself to reach its peak speed potential.

Thus, because Flyweight allows the athlete to train eccentric force at high speed, the benefits of Flyweight uniquely apply to athletic performance.

A CLOSER LOOK: THE FLYWEIGHT SLAM

I. *The 10lb Flyweight slam vs. the 225lb Barbell Clean & Jerk*

Data	**Unit**	**Flyweight Slam**	**Clean & Jerk**	**Flyweight Difference**
Output				
Peak Velocity	MPH	21.8	4.8	Flyweight + 349%
Power	kW	4.10	3.31	Flyweight +24%
Work Over 30 s	kJ	26.0	17.4	Flyweight + 49%
Muscle Activation				
Gluteus maximus	mV	1.11	0.51	Flyweight + 119%
Obliquus externus abdominis	mV	0.89	0.26	Flyweight + 241%
Latissimus Dorsi	mV	0.37	0.75	-51%
Rectus abdominis	mV	0.78		
Rectus femoris	mV	0.32		

[3] Hedayatpour, Nosratollah, and Deborah Falla. "Physiological and Neural Adaptations to Eccentric Exercise: Mechanisms and Considerations for Training." *BioMed research international* vol. 2015 (2015): 193741. doi:10.1155/2015/193741

PERFORMANCE

The Barbell Clean and Jerk Produced greater force output (2,335N v. 502N), while the Flyweight Slam outperformed in Peak Velocity, Peak Power and Work Done:

A. the Flyweight Slam moved 349% Faster

B. The Flyweight Slam generated 24% Greater Peak Power

C. The Flyweight slam resulted in 49% more Work Done

MUSCLE ACTIVATION

The clean and jerk produced greater activation of the Latissimus Dorsi (lats), while the Flyweight slam produced greater muscle activation in every other common muscle group tested (the abs and glutes).

A. Flyweight slam produced 128% greater gluteus maximus activation

B. Flyweight slam produced 128% greater obliquus externus abdominis (obliques) activation

II. The 10lb Flyweight slam vs. the 10lb Medicine Ball Slam

Output	**MPH**	**21.8**	**17.8**	**22%**
Peak Velocity				
Power	kW	4.10	2.80	47%
Work Over 30 s	kJ	26.0	11.4	129%
Muscle Activation				
Gluteus maximus	mV	1.11	0.15	627%
Obliquus externus abdominis	mV	0.89	0.40	121%
Rectus abdominis	mV	0.78	0.24	224%
Rectus femoris	mV	0.32	0.20	63%
Latissimus Dorsi	mV	0.37	0.45	-9%

PERFORMANCE

A. The Flyweight Slam moved 22% Faster

B. The Flyweight Slam generated 47% Greater Peak Power

C. The Flyweight slam resulted in 129% more Work Done

MUSCLE ACTIVATION

The medicine ball slam produced greater activation of the Latissimus Dorsi (lats). The Flyweight slam produced greater muscle activation in every other muscle group tested.

627% more gluteus maximus activation.

121% more oblique activation

224% abdominals activation

63% more quad activation

CONCLUSION

The data support that the Flyweight is a novel device designed around fundamental biomechanical principles and emerging athletic training science that can help bridge gaps between how athletes exercise and how they must perform in their sport. As the data demonstrates, Flyweight can be uniquely effective over traditional equipment in training aspects of movement that are key to athletic function and highly efficient in effectuating body composition changes in an athlete.