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Taiji's Structural Push Force and Explosive Force of the Bow Stance

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Abstract: This paper presents the first scientific experiment on the combative function of Taiji. The force generated in a bow stance comes from many factors, two of which are structural force and explosive force. Three scales were used for measurement: the front scale measured the weight borne by the front foot, the rear scale measured the weight borne by the rear foot, and the wall scale measured the horizontal force generated by the bow stance. The experiment consisted of two parts: the structural force and the explosive force of the bow stance. Structural force experiments demonstrate that the bow stance is typically a force-disadvantage lever: the entire body acts as the lever, gravity is the driving force, the structural horizontal force is the resistance, the balance degree is the driving arm, and the connecting hand height is the resistance arm. Therefore, heavier individuals can generate greater structural force. Although gravity is the driving force, the structural horizontal force originates from the friction between the soles of the feet and the ground, continuously transmitted through the entire body to the connecting hand, where the force is applied to the opponent. The wall scale acts as the opponent, objectively measuring the horizontal force. Structural force experiments have proven that the bow stance is suitable for generating pushing force, and the lower the bow stance, the greater the horizontal structural force generated. However, the horizontal structural force generated has an upper limit. This upper limit can be calculated using the simple formula presented in this paper. For more complex situations, the formulas and software described in "Calculating Taiji and Martial

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Arts" can be used. Explosive force experiments have shown that explosive force is related to the practitioner's skill level. Greater explosive energy, shorter explosion time, and greater body weight result in greater explosive force upon impact. The relationship between explosive force and stance is not significant; in other words, there is not much difference in explosive force whether the stance is a bow stance or a horse stance. The formulas and software in "Calculating Taiji and Martial Arts" can be used to calculate explosive force.

Keywords: Taiji, Push Force, Explosive Force, Bow Stance, Scientific Experiment

1. Introduction

There are very few experimental reports in the field of Taiji and traditional martial arts. There are many legends, such as the story of Yang no-enemy and the legend of Huo Yuanjia. However, legends are not documented by referees and cannot serve as evidence of the superior skills of traditional martial arts.

There have been some competitive matches in traditional martial arts, such as the national martial arts tournament in 1928 and the match between Wu Gongyi and Chen Kefu in 1954. These matches:

1. lacked the style of traditional martial arts routine.
2. had no well-defined regulations;
3. were simply about who won and who lost.

The outcome depended on the skill and technique of both participants but also involved elements of chance and luck. Later, Ma Baoguo was knocked out in 30 seconds, and Lei Lei was beaten to tears. Neither legends nor competitions constitute experiments. An experiment is a systematic practical activity that tests theories or discovers new laws through measurement under specific conditions. Its core principle is reproducibility, meaning that consistent results can be obtained under the same premises and procedures. This article presents the first experiment conducted to validate Taiji. It involved setting specific conditions, using measuring equipment, and verifying a theory.

Force is the interaction between objects and is the cause of changes in an object's state of motion. The force used in Taiji fully conforms to these properties. The mechanical definition of strength is momentum. Taiji's strength completely conforms to this definition. The strength in other martial arts also follows this definition. Taiji has sequential strength and explosive strength. Taiji's sequential

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strength includes supporting momentum, translational and rotational momentum of the body, and translational and rotational momentum of the connecting hand. The force delivered by sequential strength can also be called structural force. Structural force is the force that a posture can withstand or exert in a static state. Taiji's explosive strength is the translational and rotational momentum generated by the relative movement of the limbs. The force generated by the explosive strength can be called explosive force.

Explosive force is generated by relative, opposing movements between body parts. The arm muscles unleashed a burst of stretching energy, due to the conservation of overall momentum, the body's momentum is directed backward, the connecting hand's momentum exerts a forward horizontal force. Three scales are used to measure the force performance of a bow stance.

Let's start by conducting experiments on structural forces. See Figure 1, the rear scale measures the vertical load supported by the rear legs. The front scale measures the vertical load supported by the front legs. The horizontal structural force originates from the horizontal frictional forces at the soles of the feet, continuously transmitted through the body to the connecting hand. The connecting hand launches a horizontal attack against the opponent, the wall-mounted scale measures horizontal attack force. When the connecting hand doesn't exert any force, the readings from the front and rear scales indicate the weight supported by each leg. When the connecting hand gradually increases the force magnitude, the reading on the front scale decreased, and the reading on the rear scale increased. Until the reading on the front scale reaches zero, at this point, the wall-mounted scale shows the maximum force generated by the bow stance.

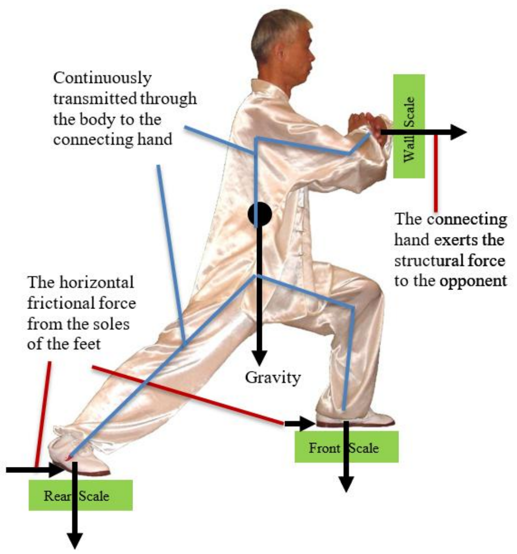

Figure 1. Three scales are used to measure the structural force of a bow stance

See Figure 2, when no force is applied, the front scale reads 80 jin and the rear scale reads 40 jin. The distance between the feet is 0.6 meters, and the connecting hand height is 1.5 meters. Calculated weight: 120

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jin, distance from front foot to center of gravity: 0.2 meters.

2. Measurement data

1. Wall scale: 0 jin, front scale: 80 jin, rear scale: 40 jin.
2. Wall scale reading: 7.3 jin, front scale reading: 60 jin, rear scale reading: 60 jin.
3. Wall scale: 14.5 jin, front scale: 40 jin, rear scale: 80 jin.
4. Wall scale reading: 21.7 jin, front scale reading: 20 jin, rear scale reading: 100 jin.
5. Wall scale: 29 jin, front scale: 0 jin, rear scale: 120 jin.

After the fifth set of data, even with the front leg lifted, the wall scale still read 29 jin, unable to improve. A zero reading on the front scale traditionally signifies a loss of foot root.

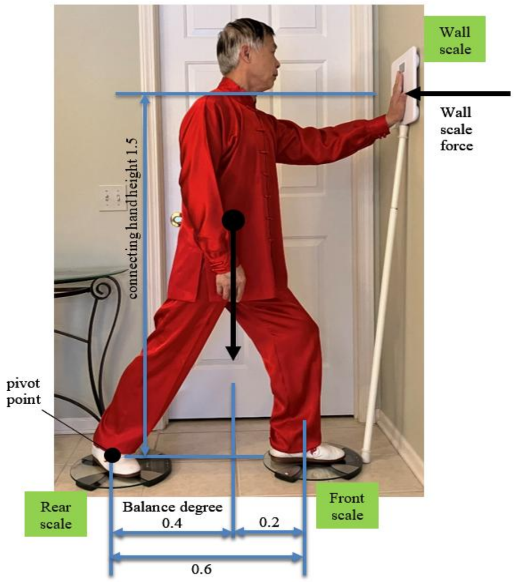

Figure 2. Experimental data on the structural forces of a bow stance

See Figure 3, Structural force has an upper limit. The balance degree of the pushing bow stance is determined by the distance from the center of gravity to the rear foot. Exceeding the upper limit of structural force will cause one of the legs to lose its foot root, losing one's foot root is the starting point of losing balance. Structural force is the leverage generated by one's own gravitational force.

The pivot point is the rear foot, gravity is the driving force, the driving arm is the balance degree, and the wall's reaction force is the resistance, the resistance arm is the connecting hand height. Take the moment of the pivot point. Wall scale force × connecting hand height = gravitational force × balance degree. In this example: Theoretical wall scale force $=\frac{120\times0.4}{1.5}$ = 32 jin. The error between measurement and theory = $\frac{32-29}{40}$ = 9.3%. Because the applied force is less than the gravitational force, this is a disadvantageous lever. Although gravity remains constant, the horizontal force generated increases as the bow stance lowers.

Therefore, the lower the bow stance, the greater the structural force generated. This means that the bow stance is suitable for

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generating pushing force. This is why the stance used for pushing a cart resembles a bow stance. Generally, the bow stance is a force disadvantageous lever, and only in extremely low bow stance positions might it become a force advantage lever. While an extremely low lunge might look impressive in a routine performance, it may not be practical in combat, and the force advantage ratio is not very high. For calculations involving complex situations, please refer to the software described in "Calculating Taiji and Martial Arts."

Gravity multiplied by the degree of balance defines the supporting momentum. Supporting momentum, translational momentum, and rotational momentum all have the same dimensions. Therefore, they can be combined in calculations.

Let's conduct another experiment on explosive force. See Figure 3, The experimental setup is the same as in Figure 1, except that the readings of the front and rear scales remain essentially unchanged during the explosive force generation. The rear scale measures the weight supported by the rear legs. The front scale measures the weight supported by the front legs. The explosive force comes from the relative movement between the connecting hand and the body, it has nothing to do with the friction between the soles of the feet and the ground, or the weight supported by the feet. The connecting hand's explosive force applies horizontal attack force against the opponent. The wall scale measures horizontal attack force.

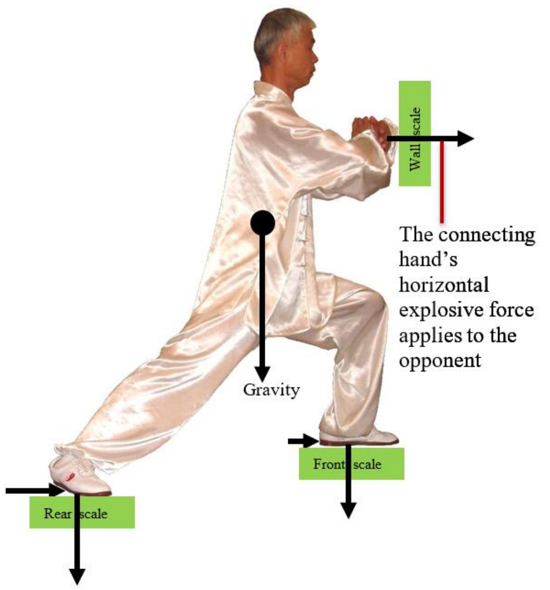

Figure 3. Three scales are used to measure the explosive force of a bow stance

See Figure 4, the left arm suddenly extended, and the upper body moved backward by a distance of Δ from position A to position B in a short period of time, causing the left palm to push against the wall scale. The backward movement and momentum of the body provided the explosive horizontal force to the left palm.

Measurement data：

1. With no relative motion, the wall scale reads 0 jin.

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2. Gentle relative speed pushes the connecting hand, the wall scale reads 10 jin.
3. Fastest relative speed pushes the connecting hand, the wall scale reads 20 jin.

After the third set of data, the experimenter had reached the limit. The speed of the connecting hand was not measured with a speedometer. The mass of the connecting hand was not measured. The front scale reads 80 jin, and the rear scale reads 40 jin; their readings do not change significantly during the explosive force application process. Explosive force has little to do with the connecting hand height. Explosive force has little to do with the structure of the posture.

The force generated by the explosive strength is correlated with the body weight providing support, the explosive energy of the muscles, and the weight of the connecting hand. The energy causes the body and the connecting hand have opposite speed directions. The product of speed and mass is momentum. The momentum of the connecting hand collides with the wall scale (or the opponent), generating force. Therefore, the force generated by explosive strength is closely related to the skill level of the practitioner. It is said that both Ali and Bruce Lee could deliver a punch with a force of 400 pounds, Alibaba has an advantage in terms of large weight, Bruce Lee had an advantage in speed.

A

B

Figure 4. Explosive force process

Structural force and explosive strength can be used simultaneously. At this point, the friction force from the soles of the feet is transferred to the connecting hands through the bow stance. See Figure 1, at this point, the front scale reading was 0, the rear scale reading was 120 jin, and the structural force on the wall scale was 29 jin.

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At the same time, the connecting hand pushed at the fastest possible relative speed. See Figure 4, the wall scale read an explosive force of 20 jin. Experimental results using both structural force and explosive force simultaneously: the wall scale reads 47 jin. The error is $\frac{49-47}{48}$ = 5%.

3. Summary

The structural force of a bow stance is the force that the bow stance can withstand or deliver in a static state. More generally: the structural force of a martial arts posture is the force that the posture can withstand or deliver in a static state. Structural force is generated by the supporting momentum. Explosive force is generated by the opposing momentum of the body relative to the connecting hand.

Explosive force is not significantly related to the structure of the posture. This is because the main factors influencing the body's opposing motion are the body's mass and degree of freedom of movement, and it is not really affected by whether the body is supported by a horse stance or a bow stance. In the experiments, the wall-mounted scale showed the force exerted on the opponent: the first experiment showed structural force; the second experiment showed explosive force; and the third experiment showed the combined effect of structural and explosive forces.

One reason why structural force and explosive force can be superimposed is that both are measured in units of force. Furthermore, both are generated by momentum: in this experiment, structural force is generated by the supporting momentum of the bow stance, and explosive force is generated by translational momentum. Generally, the force applied to an opponent is generated by a combination of sequential strength and explosive strength. Sequential strength includes supporting momentum, translational and rotational momentum of the body, and translational and rotational momentum of the connecting hand.

Explosive strength is explosive translational and rotational momentum. These factors are all included in the formulas and software algorithms of "Calculating Taiji and Martial Arts." The experiments here provide preliminary confirmation of the theories presented in " Calculating Taiji and Martial Arts." Of course, more in-depth experiments, including those using professional instruments, statistically significant control group experiments, experiments covering a large number of Taiji and martial arts postures, experiments on routine training,

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and experiments on health benefits, are yet to be conducted. The experiments here are simple yet effective, opening a whole new field of experimental Taiji. The experimental equipment used is inexpensive and readily available, encouraging Taiji practitioners to try these experiments themselves.

4. Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

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7. Open Access Statement

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