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An Investigation of the Tri-Bar Gripping System on Isometric Muscular Endurance

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Abstract. Drury, D.G., H. Faggiono, and K.J. Stuempfle. An investigation of the tri-bar gripping system on isometric muscular endurance. *J. Strength Cond. Res. 18(4):782–786. 2004.*—Recently, a new product called the Tri-Bar has been introduced as an alternative to the standard round weightlifting bar. The Tri-Bar has the same weight, length, and circumference as a standard weightlifting bar and differs only in that the shape of the bar is formed like a triangle with rounded edges. Theoretically, the shape of the bar will enhance gripping comfort and increase muscular endurance. We studied 32 moderately trained males who were free from upper-body injury or limitation. Each participant completed 4 visits to the lab as part of 2 separate investigations. The first investigation was a comparison of straight-arm hang times while grasping a standard Olympic bar or a Tri-Bar attached to the top of a power rack. The second investigation involved grasping a standard revolving cable handle or a Tri-Bar revolving handle attached to a weight equal to half the subject's body weight. In both investigations, time was used as a measure of isometric muscular endurance. Differences were determined using a dependent *t*-test, and a level of significance was set at $p < 0.05$. Mean hang times were significantly longer when the men hung from the Tri-Bar (107.6 seconds) versus the standard bar (95.4 seconds) ($p = 0.015$). Conversely, in the investigation using the revolving handles, the round bar produced longer grasping times (71.5 seconds) than the Tri-Bar (62.6 seconds) ($p = 0.000$). The results of this investigation indicate that a fixed and stable Tri-Bar may help to increase hang time, but a Tri-Bar free to rotate within the grasp may decrease grasping time in comparison to a standard round handle. With regard to exercises that require isometric grasping, the Tri-Bar may be an effective alternative to the standard bar for increasing isometric grasping endurance.

Key Words. prehensile, weightlifting bar, grasp endurance

Introduction

An alternative to the traditional Olympic bar (TOB) is now available for strength training activities (12). The Tri-Bar Gripping System (TBGS) has been marketed for several years as a more anatomically-correct match to the human hand that promotes a more natural and comfortable grip (12). (Figure 1.) Theoretically, the shape of the bar will enhance gripping comfort and increase muscular endurance. Although these claims are not directly supported by the literature, there is some evidence that a triangular gripping shape may be more advantageous for gripping endurance (4). In light of the lack of literature regarding this new gripping system, an investigation seemed warranted.

Hand prehensile force (grip strength) is a necessary and vital aspect of many occupational and sporting activities. Numerous studies have been reported regarding peak gripping strength, but very few studies have focused on the shape and size of the objects being gripped as a factor in determining muscular performance (4). The actual shape of a handle or an object being gripped in relation to the anatomical profile of the hand may help enhance or inhibit muscle efficiency (8, 10). This relationship may have increased importance when considering the muscular requirements associated with many sports, especially Olympic lifting and power lifting (1).

Most upper-body weight training activities involve the gripping musculature of the forearm and finger flexors. These muscles are very important, because in many cases they serve as the crucial interaction point of the body to the source of resistance. The isometric contraction of the gripping musculature allows other muscles of the upper body to be "connected" to the forces that will be translated through the skeletal system will and ultimately provide the overload stimulus (13). Multi-joint dynamic constant external resistance movements such as the pull-up, deadlift, power clean, snatch, and clean and jerk can put demands on the gripping musculature that more than exceed 2 times the lifter's body weight (13). Performance in these activities is often limited by the athlete's ability to maintain his or her grip on the bar during the explosive phases of these lifts (9). Furthermore, the safety of the lifter can also be compromised when grip strength is not sufficient to complete an exercise.

As the endpoint of the kinetic chain that connects an athlete to the resistance during weight training, the shape of the bar may be an unintended limiting factor for the translation of muscular force. The TBGS offers an alternative gripping shape while maintaining the other characteristics of an Olympic bar. The TBGS has not been clinically tested, and the effectiveness of this system as a means to increase gripping comfort and performance remains only theoretical. Therefore, the objective of this study was to compare the gripping performance of young men while grasping a bar with the TBGS as compared to the gripping performance while using a TOB.

Methods

Experimental Approach to the Problem

To our knowledge, there has been no data published regarding the biomechanical, physiological, or performance effectiveness of the TBGS. The present study was designed to determine whether the unique design of the TBGS would increase muscular endurance of the gripping musculature. Two separate investigations were included as part of the protocol. First, bilateral (2 hands) body weight hang time using a traditional 7 ft, 45 lb Olympic weightlifting bar was compared to a 7 ft, 45 lb Tri-bar. The bars were affixed to the top of an immovable weightlifting power rack and were secured to prevent any rotation (Figure

FIGURE 1. A cross-sectional view of the Tri-Bar.

FIGURE 2. Straight-arm hang equipment set-up.

2). The second investigation involved unilateral revolving cable handles (round standard and TBGS; see Figure 3). Fifty percent of the participant's body weight was added into a 5-gallon bucket. Two more trials were performed using each type of handle. The ability of an individual to freely support the relative resistance was calculated using time as the dependent variable.

Participants performed maximal grip endurance tests on 4 separate days. A minimum of 48 hours separated each trial. The bilateral full body weight hanging investigation was conducted first and the unilateral (1-handed) revolving cable handle investigation followed. The order in which the subjects performed each maximal test was randomly assigned. On the first day of testing, each participant completed a document of informed consent and a health history form prior to participation. Once it was determined that the subject was qualified for participation, various anthropometric measures were obtained (height, weight, body composition). The Slippery Rock University Institutional Review Board approved the protocol and all the related forms for this study prior to the collection of data.

FIGURE 3. Tri-bar swivel-handle.

Subjects

Thirty-two male volunteers without any overt signs of disease or physical impairment were recruited. Based upon guidelines published by the American College of Sports Medicine (ASCM), all men were screened and classified as being "Low Risk" for exercise participation (7). Subjects were screened using a health history questionnaire to ensure that they were healthy and free from any history of injuries or impairments to the shoulder, upper arm or hand. All men had a minimum of 6 months of weight training experience and were accustomed to lifting weights that exceeded their own body mass. A summary of the anthropometric characteristics of the population studied can be found in Table 1.

Table 1. Description of the subjects; values expressed as mean ± *SD* (range).

Height (cm)	Weight (kg)	Body fat (%)
177.5 ± 8.4 (162.6–195.6)	85.7 ± 12.9 (62.6–110.7)	11.0 ± 5.0 (4.8–23.4)

Procedures

During the first testing session, anthropometric measures were taken prior to data collection. A Detecto stadiometer/scale was used to ascertain height and body mass to the nearest cm and kg, respectively. Body mass was measured with shoes to determine the actual resistance the participant would encounter while hanging. Lange skinfold calipers were used to perform a 3-site (chest, abdomen, thigh) determination of body density and body composition was extrapolated from this data using a formula by Jackson and Pollock (7). Fifty percent of the participant's body mass was then calculated and used later as the resistance for the 1 arm revolving grip trials.

Body Weight Hanging Trials. The weightlifting bars used for this trial (TBGS and TOB) were both firmly attached to the top of a large power rack approximately 45 cm apart and 2.5 m in the air. After a brief 3-minute warm-up on a cycle ergometer, the men were guided through a variety of upper-body and upper extremity stretches that were held statically for 15 seconds each. The subject then chalked his hands thoroughly to minimize differences in friction caused by skin oils and sweat. After the warm-up procedures were completed, the men were given both a visual and verbal explanation of the expectations of the bilateral body weight hang trial. The trial began by determining how far apart the subject's hands would be while gripping the bar during testing. This distance was based upon shoulder width (acromium to acromium) of the subject in an effort to allow the arms to be parallel to one another while being perpendicular to the floor. This hand-width grip distance was recorded and repeated during the second trial. The participant then stepped up on a small platform that allowed him to grip the bar with both hands while still standing. An overhand grip with the thumb wrapped under the bar was maintained throughout the trials (Figure 2). The subject then stepped off of the platform into a bilateral straight-arm hanging position and the stopwatch was started. The trial was completed when the participant's grip could no longer be maintained and the subject dropped to the floor. A stopwatch was used to record the total hanging time to the nearest 0.01 second. These procedures were repeated using the alternate condition after a minimum of 48 hours of rest.

One-Armed Swivel Grip Trials. A second investigation was created to test the unilateral gripping endurance using the TBGS and TOB. The revolving cable handles used for these trials were free to swivel and rotate (Figure 3). Once again, the order of these trials was randomly assigned. After a brief demonstration of the proper gripping procedures, a 5-gallon bucket was filled with a weight equal to 50% of the subject's body weight. A standard carabiner was used to connect the handle of the weighted bucket to the gripping system being tested. Prior to lifting the bucket to start the trial, the subject was asked to hold onto one of the vertical pillars of the power rack using his nondominant hand. The subject's dominant hand was then used to lift the weighted bucket from the floor. A slight bend of the torso in the frontal plane towards the dominant hand allowed the subject to lift the bucket from the floor without encountering the leg in any way. In so doing, the entire upper arm was allowed to hang straight down from the shoulder. Forearm position was maintained in a position of semipronation (Figure 4). The stopwatch began when the weighted bucket left the floor and continued until the bucket was dropped.

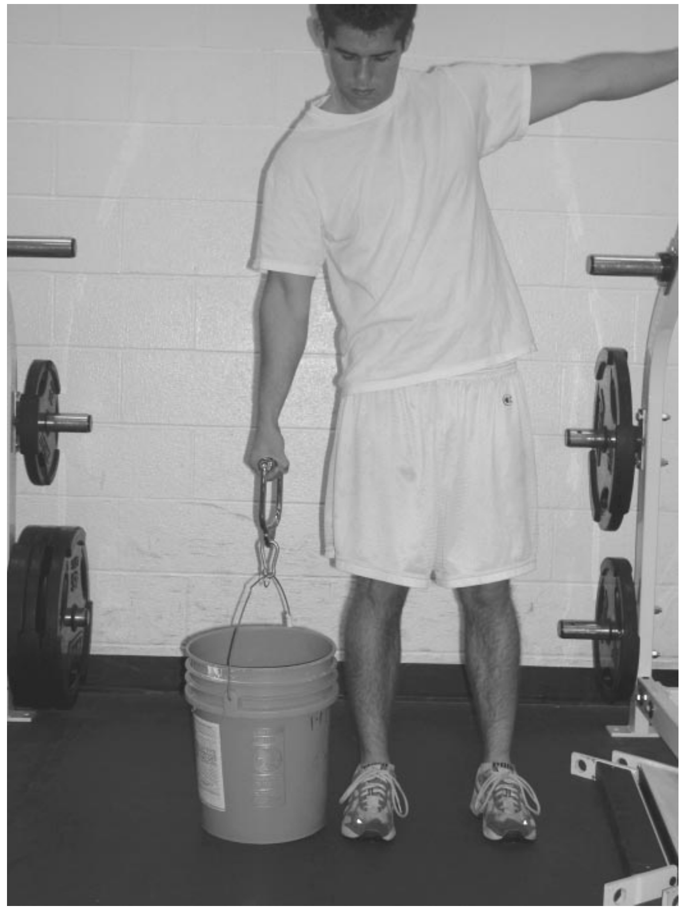

Figure 4. Unilateral endurance position.

Statistical Analyses

Differences between the muscular endurance gripping times produced while using the TBGS and the TOB were determined using a dependent *t*-test. Because each investigation was conducted using different forms of each system (bilateral fixed grip vs. unilateral revolving cable handle) the 2 procedures were analyzed separately and could not be compared to one another. The level of significance was set at $p \leq 0.05$. Because we conducted multiple comparisons on the same subjects, a Bonforroni correction factor was utilized changing our significance level to $p \leq 0.025$. The values shown are mean ± standard deviation.

Results

Body Weight Hanging Trials

The mean TBGS bodyweight hanging times were significantly higher ($p = 0.015$) than the TOB hanging times (TBGS = 107.59 ± 38.52; TOB = 95.43 ± 35.30) Figure 5.

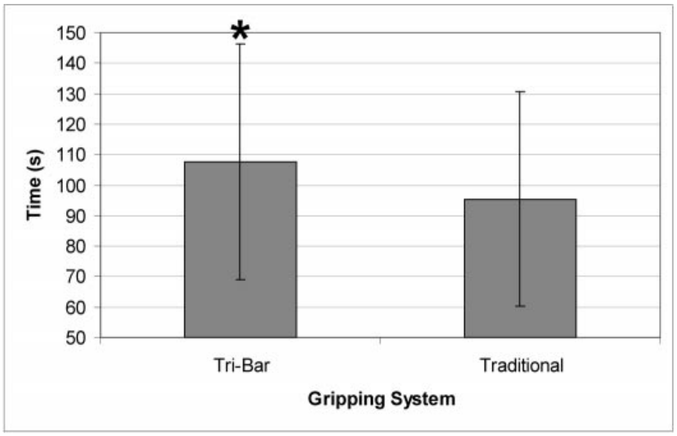

FIGURE 5. Mean (± *SD*) straight arm hang with Tri-Bar or traditional gripping system.

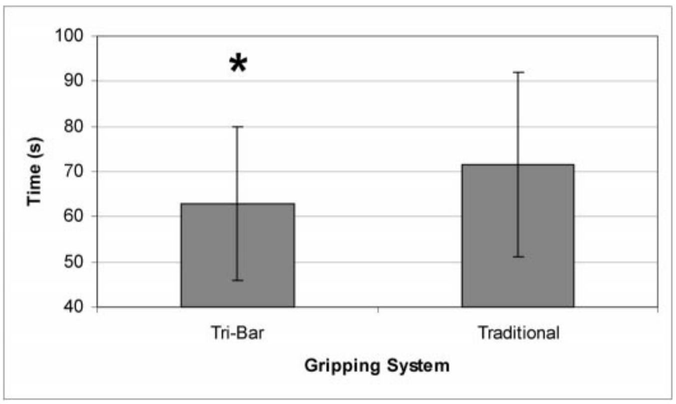

FIGURE 6. Mean (± *SD*) 1-hand grip time with Tri-Bar or traditional gripping system.

One-Armed Revolving Cable Handle Trials

The mean TBGS 1-armed revolving gripping times were significantly lower ($p = 0.000$) than the TOB 1-arm revolving cable handle gripping times (TBGS = 62.87 ± 17.14; TGS = 71.53 ± 20.46) Figure 6.

DISCUSSION

To our knowledge, this is the first investigation using the TBGS and also one of the few studies that has compared an alternative type of weightlifting bar to the TOB used by the majority of weight trainers. There are numerous factors that ultimately affect one's ability to create a maximal grip or endurance prehensile force. Gripping force has also been used extensively as a general prediction indicator of muscular fitness, a marker for neuromuscular damage, and as a measure of frailty in the elderly (11). Because the hands and ultimately the gripping forces are vital components of many weight-training activities, it seems warranted that bar and handle design would have received some attention in the sports medicine literature. Unfortunately, this was not the case.

The round TOB has had little competition with regard to its design and consequently its functional effectiveness in free-weight lifting. Although the TBGS is a relatively new product on the market, the semitriangular bar shape has been studied in the past (4). Cochran and Riley conducted an investigation comparing 36 different handle shapes and found that when 1-handed pulling forces were compared, triangular handles were significantly better than the circular handles for producing peak force (4). Although we measured gripping endurance time and Cochran and Riley used maximal force, the findings in both investigations favored the triangular design when the bar was not free to rotate. Furthermore, other researchers have found a strong relationship between gripping force and endurance (3).

Advantages to using a semirounded triangular bar can be explained by the structural variations found when comparing a round handle to a handle with angles. Theoretically, as an individual grips a bar, one of the factors that helps to maintain grip is the frictional contact between the skin and the bar (6). The importance of this relationship is demonstrated often in the field of strength training with the use of knurling and chalk to enhance the contact between the hand and the bar. When a bar is set in a fixed position and not allowed to rotate, the frictional forces of the hands are enhanced because of the fact that the skin must actually drag over the bar as the hand disengages. When the surface of this object is not uniform and round, it appears as if the hand may be better equipped to stop the slipping rotation forces that will contribute to the urge to release. Conversely, when a round bar is used, there is no interruption in the gripping surface to "catch on" that will stop the hand from slipping. These differences in bar design may have contributed to the superior TBGS hanging times found in this investigation.

Although the inventors of the TBGS do not refer to any specific published research that was used in the creation of their product, some of their claims of being "anatomically correct" may have merit. Because the bones of each finger form a series of angles that surround an object, it seems logical that a bar that could match these angles would be more biomechanically efficient. Based upon the variables measured in this investigation, we cannot speculate with any confidence that the TBGS is more or less anatomically correct. However, because this is one of the first investigations of this product we feel that a certain amount of theoretical speculation is appropriate.

In an effort to minimize the inherent muscular and biomechanical complexity of studying an isometric contraction (grip) within a dynamic isotonic movement (i.e., grip as it relates to dead lift), we chose to measure static isometric grip endurance using an isometric functional resistance (body weight). In so doing, we were attempting to limit the physiological and biomechanical variations that are inherent to the forces acting upon the wrist, forearm, and fingers during a dynamic movement. Realizing that each finger will be strongest in a different part of the range of motion, we determined that a collective isometric contraction of the finger flexors would be more sensitive to variations in gripping apparatus. In a similar historical investigation of gripping endurance, Elkus and Basmajian used a trapeze bar hang to challenge the muscles associated with gripping fatigue (6). The researchers concluded from EMG data that the amount of muscular activity did not seem to change as the hang time progressed. In other words, the amount of muscle being recruited did not decrease from the start of the hang up until volitional failure. The researchers reported that the primary reason for quitting was the perceived pain in the skin and muscles of the hand. These findings led the authors to conclude that a decrement in muscular endurance was more heavily weighted on comfort than on the fatigue of the gripping musculature. These findings may have application with regards to our investigation in that the TBGS offers an alternative shape that requires a different use of the bones and muscles of the phalanges and gripping musculature. If indeed the TBGS design has characteristics that may increase the ergonomic efficiency of isometric prehensile forces, it is possible that comfort may be enhanced, leading to an improvement in performance.

In addition to the semitriangular design of the TBGS bar, one must also consider the actual differences in circumference between these gripping systems. The TOB has a circumference of 99 mm and the TBGS has a circumference of 99 mm. The actual circumference of the bar being gripped is important because the amount of actin and myosin interaction of the gripping musculature is altered as the size of the object varies (10). Thus, each person will have a unique and specific handle circumference that will allow the greatest amount of force to be produced based upon the handle size relative to the anthropometric attributes of his or her hand (2, 5, 10). Petrofsky has reported that an alterations as little as 0.6 cm above or below an individual's optimal gripping span can decrease strength (10). Numerous studies have shown differences between men and women with regard to grip span, with women demonstrating their largest forces at a smaller grip span (5). Drury has reported that variations in handle diameters produced differences in performance, with the greatest gripping endurance forces being produced with handle diameters between 2.5 and 3.8 centimeters, depending on hand size (5). In the current investigation, the TBGS had the same circumference as the TOB. But because the shape of the bar is different, the muscles of the forearm may be recruited differently as the biomechanical advantage changes for the prehensile muscles of the fingers.

Our findings with regards to the unilateral trials also are intriguing. Based upon our results, it seems as if the TBGS can detract from gripping performance when the handle is free to rotate. When considering the physics principles that apply to these design variations, one must consider the rotational forces that are determined by the radius of each handle. With a triangular design, the radius will ultimately be longer at the peaks of the triangle in comparison to the universal radius of a circular bar. When the hand begins to lose its grip, both the triangular bar and the round bar will rotate. As the peak of the triangular bar moves further away from the rotation point, the downward force of the body might be amplified by the greater radius acting to initiate rotation. Obviously, on a circular bar the radius remains constant even during slipping or rotation. This may be a key factor in explaining the differences in performance when comparing gripping systems that rotate.

As mentioned earlier, one of the factors that may enhance gripping endurance is the frictional force of the hand with the handle. When using a bar that is secured and not allowed to rotate, the subject will begin to experience fatigue and the hand will slide over the surface of the bar as it disengages. As the hand slides over the bar the frictional force is constantly reestablished as the skin is introduced to a new part of the bar. In contrast, when the bar is free to swivel within the grasp and gripping failure begins to occur, the handle will rotate and the skin will not slide over the handle because the rotation occurs within the handle. The bar to skin relationship remains relatively constant regardless of which bar is used. Therefore, as the subject approaches muscular fatigue, he or she will disengage from the bar in a different manner depending on whether the bar is fixed or free to swivel. When the bar is fixed, the skin will pull over the bar, whereas when the bar is free to swivel, the handle will rotate.

Practical Applications

In summary, we have conducted a baseline investigation of the TBGS in comparison to the standard round bar typically found in many fitness facilities. Within the limitations of this study, we have concluded that bilateral isometric muscular gripping endurance times are improved while using the TBGS when the bar is fixed and not allowed to rotate. Conversely, unilateral isometric gripping endurance times are inhibited by the use of the TBGS when the handle is free to rotate within the hand. Based upon the limitations of this initial study, explanations of the differences between these gripping systems are speculative at best. The physiological and biomechanical factors related to gripping performance are highly complex and thoroughly interrelated. Therefore, further research is needed related to the effects of handle shape and its influence on subsequent performance of other exercises that utilize the gripping musculature.

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