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An innovative hangboard design to improve finger strength in rock climbers

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Abstract

In elite rock climbing, finger strength is critical, and is directly related to performance. A hangboard, composed of sets of artificial climbing grips to hang from, is often used by climbers to improve their finger strength. While some research has studied training protocols for climbing, virtually no published research exists addressing the specific enhancement of *training equipment* to improve training effectiveness. Here we seek to show that hangboard design, especially novel features included in the Rock Prodigy Forge hangboard increases the effectiveness of hangboard training. Recently, this hangboard was developed through an iterative process leveraging modern CAD/CAM techniques. This enabled design engineers to optimize the hangboard for improved training benefit and reduced injuries. As a result, several innovative features were added to the design including: (a) equation-driven grip edge profiles, (b) drafted pockets, (c) novel grip designs, (d) improved grip geometry, and (e) improved texture, among other features. The Forge was tested by experienced climbers, and 92% assessed it as more effective than other training tools, with 91% of users able to train harder without fear of injury relative to other training methods, and 86% reporting improved climbing performance. This is a significant and unique result for the sport of climbing.

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1. Introduction

In elite rock climbing, finger strength is critical, and is directly related to performance [1]-[3]. A hangboard, composed of 20+ sets of artificial climbing grips to hang from, is often used by climbers to improve their finger strength (Fig. 1). In 2014, a proven approach to hangboard training was published [4] along with a novel hangboard design, the Rock Prodigy Training Center (RPTC – Fig. 1, e) [5], which is manufactured by our research partner, Great Trango Holdings, Inc. The effectiveness of this training method and hangboard were studied, and shown to greatly enhance both finger strength and rock climbing performance [2]. After training, subjects showed a mean 32% increase in finger strength (defined as the amount of weight they are able to apply to various grips), and a mean improvement in overall climbing performance of 2.5 Yosemite Decimal System letter grades.

In this work we sought to once again improve the training effectiveness of the hangboard by applying an iterative design process utilizing modern CAD/CAM techniques – a novel approach in the climbing industry. The result is the Rock Prodigy Forge hangboard (Fig. 1, f) [6]. Varying grip designs were solid-modelled then 3D-printed. These prototypes were evaluated by elite climbers for ergonomics, specificity to rock, and training effectiveness. The computer-based development process allowed many more iterations than would typically be feasible for such a niche product. Individual grips could be produced, tested, and refined before assembling them into the complete hangboard, composed of 20+ grips. This enabled design engineers to optimize the hangboard for improved training benefit and reduced injuries. As a result, several innovative features were added to the design including: (a) equation-driven grip edge profiles, (b) drafted pockets, (c) novel grip designs, including a micro crimp with Distal Inter-phalangeal (DIP) joint guard, (d) improved grip geometry, and (e) improved texture, among other features. In this

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work, we describe these design features and demonstrate that these specific features directly improve the effectiveness of hangboard training, finger strength, and rock climbing performance.

2. Background: Finger strength training for rock climbing

2.1. Finger strength training on a hangboard

Hangboard training is an effective method for improving finger strength in climbers because it is possible to control and track many training variables such as grip type, resistance, and exercise duration [7], [8]. This is in contrast to other climbing exercises such as unstructured climbing or bouldering, wherein resistance and duration are difficult to control. Further, hangboard training is more sport-specific than other finger strength training methods, such as spring-loaded compression devices. A training device often used by climbers is the *campus board*, an inclined wall with vertical columns of edges that are climbed dynamically, without using footholds. Campusing is a plyometric exercise that is most effective for developing muscular *power* and coordination, so it is an important component of climbing training [9], [10]. However, it is not ideal for muscle *strength* training because it is less-controlled, only utilizes one grip position, and the protocols do not stimulate muscular hypertrophy [4].

Hangboard exercises consist of static two-arm "dead-hangs" (Fig. 1, a-c) in which both hands are used on the board at all times — with each hand on the same size and type of grip for a given set. The elbows and shoulders are slightly bent and the muscles of the upper arm, shoulder, and upper back should be flexed during each hang to support the athlete's weight. The athlete does not pull-up, or otherwise vary the body position during the repetition.

Each workout entails several sets of hangs of a set duration from a premeditated sequence of climbing-grip positions. The exercise intensity can be tuned (increased or decreased) by hanging supplemental weights from the athlete's harness (Fig. 1, b), or by attaching a weighted pulley system that assists the athlete (Fig. 1, c). This weight is also used to quantify finger strength, and has been shown to be a more reliable metric than hand dynamometers for measuring climbing-relevant finger strength [11].

Fig. 1. (a-c) Finger strength training on the RPTC hangboard and (d-f) the evolution of hangboard designs with the *Rock Prodigy Forge* (f).

2.2. Evolution of hangboard designs

Traditional hangboards (Fig. 1, d) are a single piece with a symmetric arrangement of grips. They are often designed for appearance rather than climbing-specific finger strength training. Hangboard training can lead to overuse injuries including shoulder, elbow, and wrist tendonitis, as well as injuries in the finger flexion systems (to include the flexor and extensor muscles in the forearm, flexor tendons, annular pulleys, and the interphalangeal joints in the fingers [12]). These overuse injuries may be directly caused by the traditional, single piece, symmetric hangboard design (Fig. 1, d). When training on a traditional hangboard, the athlete grabs matching pairs of grips, which are equidistant from the board's centerline. As a result, certain grip pairs may force the athlete's hands close together or far apart – neither of which are ergonomic positions – placing extra stress on the athlete's joints. The RPTC, (Fig. 1, e) was the first two-piece hangboard design which eliminated this constraint. The board's halves can be spaced at an appropriate width for the athlete and permanently mounted, or they can be attached to a movable, adjustable-width mount [13]. Early data indicates that this design is more ergonomic and less harmful [2].

The most common hangboard-related injuries are finger pad skin injuries caused by friction between the skin and grips. These may be blisters, tears, or general soreness. While minor compared to structural injuries, skin injuries are very common due to the high shear and normal stress applied to the skin. When sustained, the athlete will be unable to continue training the responsible grip position at the same intensity until the skin heals (~5 - 15 days). Therefore, skin injuries can greatly impede training.

Hangboards that were not designed for high-intensity training may have grip shapes that concentrate stress on the skin and increase the risk of skin injuries. During the development of the RPTC and continuing with the Forge, the primary design focus was creating the most effective tool for rock climbing trainin**g**. This is accomplished by maximizing ergonomics (thus, minimizing injuries) allowing athletes to train consistently at a high level of intensity, yielding the greatest gains.