A Pilot Study: The Acute Effects of a Novel Kinetic Chain Weight-Supported Resistance Training Technique

Thomas G Palmer¹* and Michael Del Re²

¹Rehabilitation Sciences, University of Cincinnati, Cincinnati, Ohio, USA
²Momentum Physical Therapy, Lawrenceburg, Indiana, USA

Abstract

Kinetic Chain Resistance Training (KCRT) has been used to promote gains in muscular strength. The Finisher® is a gravity-modified resistance devise which offers weight-supported kinetic chain stimuli. The purpose of this study was to investigate the effect of a six week pre- to post- Finisher® training intervention would have on muscular strength in 39 healthy volunteers. There were statistically significant increases in muscular endurance as measured by a push-up (p = 0.010), sit-up (p = 0.010), squat (p = 0.010), and horizontal glenohumeral joint prone abduction (p = 0.020). There was a significant moderate to strong positive correlations for each dependent variable (r = 0.58 - r = 0.88). There was a large effect size in the horizontal shoulder-abduction (0.91) and all dependent variables for the females (1.1-1.3) and small to large for the males (0.31-1). The kinetic chain weight-supported resistance of the Finisher® was effective in improving total body muscular endurance measures.

Keywords

Total body resistance training

Key Points

• Weight-supported Kinetic Chain Resistance Training (KCRT) utilizing multiple standing positions and push-pull motions on a horizontal plan was effective in improving muscular strength and endurance.
• The novel kinetic chain weight-supported resistance of the Finisher® provides a stimulus adequate to generate targeted muscles for both the upper and lower extremities.
• The intersegmental stability-mobility training techniques warranted during weight-supported horizontal push and pull patterns appears to engage synergy between the extremities and the musculature that support the proximal segments of the pelvis, spine and trunk.
• Improvements in horizontal glenohumeral joint prone abduction following the Finisher® intervention suggest the horizontal push-pull stimuli to be a potential resource for shoulder rehabilitation.

Introduction

Kinetic Chain Resistance Training (KCRT) has been widely used to implement a variety of overloads necessary to develop muscular strength, power and/or endurance [1-4]. KCRT is characterized by total body movements involving a series of multiple rigid and mobile body segments designed to work synergistically in an effort to optimize performance of a given task(s) designed to overload the musculoskeletal system [2]. Here, ground reaction forces are absorbed and transferred in a manner to generate efficiently succinct movement patterns and mimic multi-planer tasks of daily living and sport [1-4]. KCRT has been reported to target and promote increases in muscle activation, strength, power, endurance and proprioception throughout the body [3-5]. Such improvements are generally a response of a novel overload and/or the increased frequency and volume of recruited motor units created by multiple body segments acting collectively to manipulate the forces to and from

*Corresponding author: Thomas G Palmer, PhD, ATC, CSCS, Rehabilitation Sciences, University of Cincinnati, French East 275B, Cincinnati, Ohio, USA, 45221, Tel: 859-835-2852, Fax: 513-556-3898, E-mail: Thomas.Palmer@uc.edu

Received: September 01, 2017; Accepted: October 09, 2017; Published online: October 11, 2017

the proximal and distal segments [1-3]. The synchronization of multiple muscle groups improves stability at the proximal segments maximizing the efficiency of energy transfer to the extremities thus optimizing the potential to generate and transfer forces. Such gains are often associated with improvements in quality of life, self-perception and performance [3,6,7].

Close kinetic chain and Olympic style lifting techniques are two very common techniques often used to improve total body muscle capabilities. However, these lifting techniques often require the use of heavy resistance and/or skilled movement patterns which place provocative loads on the musculoskeletal system [8,9]. As a result, health care providers continue to implement resistance training exercises where the influence of gravity is altered to reduce compressive and sheer force loads on the musculoskeletal system. Weight-supporting harnesses, unilateral cane mobility and hand/foot/limbed supported table slides are common examples of gravity-modified exercises. Often these techniques are reported to support the resistance in a fashion that alters loads yet have similar benefits to traditional resistance training [10]. Such exercises involve resistance training in which movement is neither assisted nor hindered by gravitational forces but provides an overload to the musculoskeletal system [10]. As a result, gravity-modified exercises are often used in the rehabilitation arena to improve muscular strength while reducing joint loads and mitigating the risk of musculoskeletal injury.

The Finisher® (Finishing Fitness, Inc. West Harris, Indi-

Figure 1: The Finisher® exercise device.

Figure 2: Example of a Finisher® exercise movement.
ana), displayed in Figure 1 and Figure 2, is a kinetic chain weight-supported device which allows for the modification of resistance and the influences of gravity. The versatility of the device allows for a variety of lower and upper body kinetic chain positions while implementing different weight shifting and multi-planar movement patterns seen in Figure 3a and Figure 3b. The adjustable height and reduced friction surface of the slide board allows the resistance to be pushed and pulled in various directions and heights in weight-bearing positions with limited compressive loads on the musculoskeletal system. Thus, our hypothesis was the Finisher® could promote improvements in muscular strength via KCRT [4]. However, little is known regarding the effect the Finisher® has on health-related components; such as muscular strength or endurance. Therefore, the purpose of this investigation was to evaluate the effect of a KCRT program performed over six weeks on the Finisher® would have on general muscle endurance.

Methods

Participants

A randomized convenience sample of thirty-nine healthy volunteers from a local fitness club (26 females and 13 males) with the average age 34 ± 4 years; height 168.5 ± 6.2 cm; weight 73 ± 4.4 Kg) were tested; Table 1. All subjects reported participating in routine weight and cardiovascular training sessions a minimum of 30 minutes, 3 times per week. Inclusion criteria were set at no reported injuries/pain prohibiting participation in the exercise or testing. Prior to testing all participants reviewed and signed an official institutional review board medical clearance and an informed consent to participate in the study. Each participant was asked to discontinue current training routine, abstain from any muscle compounding supplements and to follow a Finisher® training intervention exclusively (Table 1).

Figure 3a: Finisher motion patterns for the upper extremity.
Arrows indicate the direction the weight is moved across the table with the arms while maintaining an athletic stance.

Table 1: Participant demographics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Female pre-test N = 26 Mean ± SD</th>
<th>Female post-test N = 26 Mean ± SD</th>
<th>Male pre-test N = 13 Mean ± SD</th>
<th>Male post-test N = 13 Mean ± SD</th>
<th>Total pre-test N = 39 Mean ± SD</th>
<th>Total post-test N = 39 Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height, cm</td>
<td>164.5 ± 6.2</td>
<td>164.5 ± 6.2</td>
<td>173.8 ± 8.4</td>
<td>173.8 ± 8.4</td>
<td>169.9 ± 7.2</td>
<td>169.9 ± 7.2</td>
</tr>
<tr>
<td>Weight, Kg</td>
<td>63 ± 5.4</td>
<td>61 ± 5.3</td>
<td>83 ± 3.3</td>
<td>82 ± 3.3</td>
<td>73 ± 4.4</td>
<td>72 ± 4.4</td>
</tr>
<tr>
<td>Age, years</td>
<td>35 ± 5</td>
<td>35 ± 5</td>
<td>32 ± 5</td>
<td>32 ± 5</td>
<td>33 ± 5</td>
<td>33 ± 5</td>
</tr>
</tbody>
</table>
Participants performed each test and received a 4:1 work to rest ratio between tests. Participants completed as many repetitions as possible within one-minute. A team of certified athletic trainers, physical therapists and certified fitness experts with a combined 40 years of experience monitored each test, assured proper form and counted repetitions for each test.

a. The Push-up Test was performed using a traditional position and modified kneeling position for the males and females, respectively. Participants were required to lower the chest below the elbows and to maintain an erect posture in the ascending and descending positions [3-5]. Repetitions were not counted if the hip, spine or torso became flexed/extended or rotated.

b. The Sit-up Test was performed in a traditional supine position with knee flexion to 90 degrees and arms folded across the chest. A repetition was counted if the inferior angle of the shoulder blades lifted off and touched the ground [3-5].

c. The Squat Test was unweight and performed from a standing hands on hips position. Participants were required to descend from full knee extension to 90 degrees of knee flexion [3-5].

Figure 3b: Finisher motion patterns for the torso and lower extremity. Arrows indicate the direction the weight is moved across the table while incorporating various combinations of torso rotations and leg exercises.
Data analysis

All data was analyzed using SPSS-23, IBM. Data was assessed for normality using a Mann-Whitney U test. A paired sample t-test was used to assess pre- to post-test statistical significant differences for all dependent variables; push-up, sit-up, squat, prone horizontal shoulder abduction. An independent t-test was used to assess sex differences at pre- and post-test for all variables. A Pearson Product Correlation Coefficient displayed in Table 2 was used to assess relationships between all dependent variables. A priori significance level was set at $p \leq 0.050$. A power analysis was performed to assess the treatment Effect Size (ES) of the Finisher® intervention for each dependent variable. ES was based on a Cohn’s $d$ calculation; respectively the intervention group means from pre- to post-test were subtracted to represent a true control group and divided by a pooled standard deviation to determine the effect of each intervention [12]. ES data are displayed in Table 3 and Table 4. Results were interpreted as small (0-0.39), medium (0.40-0.69) or large ($\geq 0.70$) [13].

Results

It was hypothesized that there would be a statistically significant increase ($p \leq 0.050$) in all dependent variables following a six week training period with the Finisher®.
er®. Table 5 indicates the push-up, sit-up, squat and the glenohumeral joint horizontal abduction tests had significant improvements pre- to post-intervention which supports the hypothesis that the Finisher® intervention would improve strength and endurance test measures in each dependent variable.

Females had a significantly greater increase in the push-up (p = 0.010) following the Finisher® intervention. There was no significant sex difference for all other dependent variables at post-intervention as reported in Table 6.

There were moderate to strong positive correlations for each dependent variable as reported in Table 2. The strongest correlations were found between the squat and sit-up (r = 0.88) and the squat and shoulder abduction (r = 0.81). The remaining correlations were moderate between the push-up and sit-up (r = 0.63), the push-up and squat (r = 0.75), the push-up and shoulder abduction (r = 0.58) and the sit-up to squat (r = 0.73).

The treatment effect from pre-to post-test was further analyzed by calculating an Effect Size (ES) with corresponding 95% Confidence Intervals (CI) for each dependent variable [12]. Prone horizontal glenohumeral joint abduction had a strong effect size for the entire group (0.91) while the remaining variables had moderate to small effects (0.27-0.66). Sex effect sizes were large for all dependent variables for the females (1.1-1.3) and small to large for the males (0.31-1) Table 3 and Table 4.

Discussion

The novel total body kinetic chain stimuli provided by the Finisher® was adequate to promote improvement in each of the dependent variables. The statistically significant improvements in each test indicate the Finisher® provides loads that generate targeted muscle activations for both the upper and lower extremities. The transfer of energy about the kinetic chain is likely a result of proximal stability about the pelvis, spine and trunk [14]. Previous literature has reported increases in muscular strength at the proximal segments with KCRT as a result of increased muscle activation [14-16]. The standing position often limits the amount of force the whole body can produce, however it enhances muscle activation about the proximal muscles which provides a stable base for the limbs to transfer and absorb forces [14]. Santana, et al. demonstrated inferior force output from a standing cable row verse a flat bench press; however the standing resistance had superior spine and trunk muscle activation [4]. A majority of the training on the Finisher® was from a standing position while the arms pushed and pulled a resistance. The synchronization of multiple muscle groups and redistribution of gravity appears to improve stability at the proximal segments maximizing the efficiency of energy transfer to the extremities. The end result being improved ability for the extremities to generate and sustain forces [4,8]. Our data suggests the improvement in the individual tests resulted from a variety of multi-planar loads offered by the Finisher® at the torso and the extremities from a standing position. Although not directly measured, improvements in these types of muscular strength performance are likely a result of morphological changes combined with enhanced neuromuscular activation between the proximal and distal kinetic chain musculature [4]. Such benefits are not uncommon for total body resistance training, however the weight-supported mechanism likely offers unique load transfers with likely less compressive loads.

Closed kinetic chain training or total body resistance training similar to that provided by the Finisher® has been reported to impact performance in strength movements, sport performance and in the rehabilitation of injury [3,17-19]. However, the sliding platform and the push-pull/acceleration-deceleration moments seem to offer a different type of overload not seen in traditional kinetic chain train-

Table 5: Total group pre-to post-comparison of dependent variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-test Mean ± SD</th>
<th>Post-test Mean ± SD</th>
<th>Percent change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push-up</td>
<td>28 ± 14</td>
<td>36 ± 15</td>
<td>29</td>
<td>0.010</td>
</tr>
<tr>
<td>Sit-up</td>
<td>37 ± 14</td>
<td>46 ± 16</td>
<td>24</td>
<td>0.010</td>
</tr>
<tr>
<td>Squat</td>
<td>42 ± 15</td>
<td>46 ± 15</td>
<td>10</td>
<td>0.010</td>
</tr>
<tr>
<td>Horizontal abduction</td>
<td>35 ± 9</td>
<td>46 ± 16</td>
<td>31</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Table 6: Independent sex differences of dependent variable.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Female pre-test Mean ± SD</th>
<th>Female post-test Mean ± SD</th>
<th>Percent change</th>
<th>Male pre-test Mean ± SD</th>
<th>Male post-test Mean ± SD</th>
<th>Percent change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push-up</td>
<td>31 ± 9</td>
<td>41 ± 16</td>
<td>48</td>
<td>46 ± 20</td>
<td>46 ± 20</td>
<td>12</td>
<td>0.010*</td>
</tr>
<tr>
<td>Sit-up</td>
<td>46 ± 13</td>
<td>45 ± 15</td>
<td>44</td>
<td>52 ± 20</td>
<td>62 ± 15</td>
<td>16</td>
<td>0.080</td>
</tr>
<tr>
<td>Squat</td>
<td>49 ± 14</td>
<td>52 ± 16</td>
<td>36</td>
<td>62 ± 15</td>
<td>62 ± 15</td>
<td>19</td>
<td>0.710</td>
</tr>
<tr>
<td>Horizontal abduction</td>
<td>44 ± 11</td>
<td>38 ± 10</td>
<td>38</td>
<td>48 ± 15</td>
<td>48 ± 15</td>
<td>26</td>
<td>0.330</td>
</tr>
</tbody>
</table>

*Significance difference at p ≤ 0.050, F = F value for independent sample test with equal variance, df = Degrees of Freedom for independent sample test with equal variance.
push and pull patterns of the Finisher® weight out from the center of the body's mass. The unique range of motion that is not restricted when propelling the athlete to train in several degrees of freedom which can enhance the training outcomes of traditional style resistance training verse a Finisher® intervention. Further investigation is needed to investigate the cause and effect relationship of the Finisher® and its effects on sport, rehabilitation, and fitness parameters is not fully understood, but pose as a sensible training stimulus.

The Finisher® seems to provide advantageous overloads that result in improved functional strength while reducing compressive loads on the body. While we did not measure compressive forces the partial weight-supported platform reduces the vertical load on body segments when compared to other Olympic style or total body lifts such as a squat. Indications from previous reports suggest partial weight-supported modification of the resistance provided by the platform results in less overall metabolic and muscle exertion when compared to traditional kinetic chain or Olympic style lifting [4,20]. However, the potential benefits from the Finisher® and related weight-supported devices are not fully understood. Weight-supported KCRT, such as, partial weight-supported treadmill and sling-suspension training are characterized by modifying the gravitational pull on the body. Our data is similar to previous kinetic chain weight-supported training; however volume and intensity dosage parameters remain under investigation. McKneill, et al. reported a reduction in metabolic expenditure and improved running efficiency as partial weight-support was increased; however the gained efficiency was not directly proportionate to the percentage of body weight supported. Pedersen, et al. and others have reported improvements in sport skills following sling-suspension training, however the only common training attribute among these studies was linked to submaximal resistances and limitations in stability, not training dosage [3,21,22]. Further, there remains limited data as to the effect weight-supported linear versus undulating progressions have on strength performance. Our data suggests that the kinetic chain resistance provided by the Finisher® models those of the sling-suspension training. The combination of off-loading the body in multiple-planes warrants the proximal segments to attain stability with the intention of optimizing distal extremity function [23]. The strength benefits and possible reduction of compressive forces proposes the Finisher® to have a potential training advantage over traditional resistance and/or rehabilitation training [24]. Investigations are warranted to examine traditional training doses verse the Finisher®. The
compared to the males (ES = 0.31-1) indicates there was a potentially greater impact on females regarding muscular endurance gains. This was likely due to a ceiling effect of the strength measures among the males. Generally speaking, males tend to carry more mass and potentially leaner muscle mass making them stronger regardless of fitness levels [11]. However, the population in the current study was physically active which indicates they had a significant degree of dedication to exercise and had good strength and fitness levels [11]. Thus, the novel training style appears to be advantageous for individuals currently participating in a regular scheduled weekly exercise program.

Our intention was to determine if the Finisher® device was effective in promoting strength/endurance gains. The overall improvements in the data provide evidence that the Finisher® is a viable training device regardless of sex. A primary limitation in the study was the lack of a matched control group as it limits the generalizability of the outcomes. Matched control studies would strengthen the generalizability of the utility for the Finisher®. Yet these outcomes indicate the Finisher® and similar techniques have promise for a multitude of training interventions. Despite these limitations, our data provides a good foundation regarding the cause and effect relationships a Finisher® intervention has on muscle gains among a general fitness population. As such, the resistance provided by the device may serve as an additional option for clinicians to progress rehabilitation and training protocols. Future research should aim to target both general fitness groups, sport and/or rehabilitation groups that require decreased compressive loads. In addition, training specificity for injury prevention and/or sport are areas to exploit in future research regarding different loading patterns and progressions of weight-supported exercise [3].

Conclusion

The Finisher® is an effective KCRT device for providing improvements in strength with a novel multi-planar weight-supported platform. The construct of the Finisher® offers weight-supported training that reduces joint loads and compressive forces. The outcomes from out study are promising but further research is needed to determine the full utility of the Finisher® for sport and rehabilitation practices.

References


