CBÜ Beden Eğitimi ve Spor Bilimleri Dergisi
CBU Journal of Physical Education and Sport Sciences
Volume: 18, Issue: 1, 2023
E-ISSN: 2149-1046
DOI: 10.33459/cbubesbd.1227537
URL: https://dergipark.org.tr/tr/pub/cbubesbd

Comparison of Muscle Activation During Toes to Bar Movement Performed with Different Techniques

Erbil Murat AYDIN[1*], Burak GÜNDOĞAN[1], Erkan DEMİRKAN[1]

[1]Hitit University, Faculty of Sport Sciences, Çorum

Research Article
Received: 31/12/2022 Accepted: 13/06/2023 Published: 30/06/2023

Abstract

With the increasing importance of physical fitness in the world, physical activity types such as CrossFit, which includes high-intensity combined movements, have become popular. The aim of this study was to compare the rectus abdominis (RA) muscle activation during the kipping toes-to-bar (KTB) and the strict toes-to-bar (STB) movements. RA muscle activation was measured during the KTB and STB exercises in 12 healthy young men. Participants performed 5 repetitions of both KTB and STB exercises in randomized order. Participants performed both exercises with a 5-minute rest interval. For comparing the RA muscle activity during the KTB and STB paired sample t-test was used. A significant difference was found between the KTB (359.56 ± 160.50 μV) and the STB (415.37 ± 185.63 μV) for RA muscle activation ($p<0.05$). These findings demonstrated that the difference in RA muscle activity during the STB and KTB movements showcases the importance of the STB movement on the RA that revealed greater motor units' activation in a non-oscillation position. The study finding emerges that the same exercise can lead to different motor unit activations in the same muscle group, depending on the way the movement is performed.
Keywords: Calisthenic exercises, Strict toes to bar, Kipping toes to bar.

Farklı Tekniklerle Uygulanan Bara Ayak Çekiş Hareketi Sırasında Kas Aktivasyonunun Karşılaştırılması

Öz

Dünyada fiziksel uygunluğun öneminin artmasıyla birlikte CrossFit gibi yüksek yoğunluklu kombine hareketleri içeren fiziksel aktivite türleri popüler hale gelmiştir. Bu çalışmanın amacı, salınımlı bara ayak çekiş (kipping toes to bar (KTB)) ve salınımsız bara ayak çekiş (strict toes to bar (STB)) hareketleri sırasında rectus abdominis (RA) kas aktivasyonunu karşılaştırmaktır. 12 sağlıklı erkek bireyin RA kas aktivasyonu KTB ve STB sırasında ölçülmüştür. Katılımcılar rastgele sıra ile hem KTB hem de STB egzersizlerini 5 tekrar gerçekleştirmişlerdir. Katılımcılar her iki egzersizi 5 dakikalık dinlenme aralığı ile gerçekleştirmişlerdir. KTB ve STB sırasında elde edilen RA kas aktivasyonlarının karşılaştırılması için eşleştirilmiş örneklem t-testi kullanılmıştır. RA kas aktivasyonu için KTB (359.56 ± 160.50 μV) ve STB (415.37 ± 185.63 μV) arasında anlamlı fark bulunmuştur ($p<0.05$). Bu çalışmanın bulguları, STB ve KTB hareketleri sırasında RA kas aktivitesindeki farkın, STB hareketinin RA üzerindeki önemini gösterdiğini ve bu da salınımsız bir pozisyonda daha büyük motor ünite aktivasyonunun ortaya çıktığını göstermektedir. Aynı egzersizin, hareketin yapılma biçimine bağlı olarak aynı kas grubunda farklı motor ünite aktivasyonuna yol açabileceği çalışma bulgusu ortaya çıkmaktadır.
Anahtar Kelimeler: Kalistenik egzersizler, Salınımsız bara ayak çekiş, Salınımlı bara ayak çekiş.

[*] **Corresponding Author:** Erbil Murat Aydın, **E-mail:** emurataydin@hitit.edu.tr

INTRODUCTION

Physical fitness has gained importance in the 21st-century world. However, recently recognized types of physical activity such as CrossFit® (CF), consisting of high-intensity and equally difficult and combined exercises, have emerged (Cook et al., 2014). CrossFit® is high intensity functional training that contains lifting (i.e., snatch, clean), gymnastics (i.e., bar/ring muscle-up, toes to bar, pull-ups), and aerobic methods (i.e., rowing, running) (Feito et al., 2018; Glassman, 2011; Weisenthal et al., 2014). These exercises are combined in the workout which is called workout of the day (WOD) and performed in rapid repetition with minimum or no resting time (Weisenthal et al., 2014). The main purpose of CrossFit training improves cardiovascular and respiratory endurance, strength, flexibility, power, speed, coordination, agility, and balance (Lichtenstein & Jensen, 2016). Besides, it has been shown that CF training effects positively body composition and resting heart rate (Bechke et al., 2017). The fitness participants enjoy this type of training (Thompson, 2017). It is equivocal that CF training has more advantages than alternative training methods for improving fitness levels (Carnes & Mahoney, 2019; Feito et al., 2019).

Reebok CrossFit Games™ (the Games) is the major CF competition. The individual winner of this competition is called "Fittest on Earth™". Although the structure of the competition changes over time (CrossFit, 2020), the first online qualifying round continued (Mangine et al., 2020).

The core has been defined as a box with the abdominals at the front, paraspinals, and gluteals at the back, the diaphragm at the top, obliques at the sides, and the pelvic girdle and hip girdle musculature serving at the bottom (Akuthota & Nadler, 2004; Hibbs et al., 2008; Shinkle et al., 2012). The core is important for the stabilization of the body and spine (Akuthota & Nadler, 2004). Abdominal muscles and paraspinal muscles are muscles that contribute to spinal stability (Chan et al., 2020). Abdominal muscle exercises are used frequently by athletes. Various static and dynamic exercises are used by athletes for abdominal muscles. These exercises are recommended for improving sportive performance, core strength, and also rehabilitation of low back pain (Youdas et al., 2008). The rectus abdominis muscle is one of the muscles that including in trunk muscles. Trunk muscles are the primary muscles for athletic performance and maintaining correct posture. The core trunk muscles are involved in many tasks of daily life, and also sports performance (Comfort et al., 2011).

One of the CF movements that many gymnasts use in their basic training is the bar pulling movement. These movements are very effective movements on the core muscles. Core muscles are also very important in all sports. Bar pulling movement can be applied as two methods. These are The kipping toes-to-bar (KTB) (oscillating) and the strict toes-to-bar (STB) (without oscillating) movement (https://www.crossfit.com, 2020). Toes-to-bar exercises are one of the most frequently used basic exercises in CF. In the KTB movement, while the person is hanging on the bar, their feet touch the bar with the leg swing. In the STB movement, while the person is hanging on the bar, their feet touch the bar without leg swing. The kipping toes to bar is easier than the strict toes to bar. No research has yet been found on the effect of the kipping toes-to-bar (oscillating) (KTB) and the strict toes-to-bar (without oscillating) (STB)

movement on young men. Therefore, this study was conducted to compare the rectus abdominis muscle activity during the KTB and STB.

METHODS

Study Design

The crossover experimental design was used in this study. 12 male volunteers (age: 21.67 ± 1.56 years; body height: 175.67 ± 5.75 cm; body weight: 69.92 ± 7.19 kg) who have been doing regular abdominal exercises for the last 3 months, participated in this study. Prior to the measurements, subjects were warned not to take caffeine or any other stimulant.

Data Collection

The exercise with which the subjects will start to work was randomly determined by dividing them into two groups. 6 subjects started working with the KTB and the others with the STB exercises. Before starting the study, subjects were met with information about the study. The subjects performed trials of the exercise. Subjects were given 1-week rest after the trials. During the study, measurements were taken for each individual in 2 sessions on different days in total. Subjects' height, weight, and body composition measurements were made in the morning in the first session. Then, the subjects were divided as randomly into the KTB and STB groups. In the second session, the muscle activation measurements of the subjects were made. Subjects performed both exercises with a 5-minute rest interval. Each subject in the study took place in both groups. In order to minimize all errors during taking measurements, individuals were informed about the importance of the subject and what should be considered by making necessary explanations before measurement applications. Measurements were taken at the same time of the day (10:00-12:00) and with the whole body rested.

Toes to Bar Exercises. In this study, subjects performed the KTB and STB exercises. During both movements, the subjects started to move on the pull-up bar in a hanging position with their feet not touching the ground. During the KTB, the subjects touched the bar with their feet from the hanging position with the help of a swinging movement. In the STB movement, the subjects touched the bar with their feet without any swinging movement from the hanging position. Subjects performed both actions in 5 repetitions. The repetitions in which the subjects touched the bar with their feet were counted.

Electromyography Measurements. Delsys Trigno 4 channel surface electromyography (EMG) device was used for muscle activation measurements. Before placing the electrode on the surface, the area was shaved and cleaned with alcohol to reduce skin impedance. All data were collected at a signal bandwidth of 20-450 Hz with a rectangular pre-magnified bipolar Ag/AgCl surface electrode (Delsys Inc., Boston, MA, USA) with a fixed inter-electrode distance of 1 cm. The raw EMG signals were sampled at 1926 Hz. Muscle activation was determined during the KTB and STB exercises. The EMG signal was collected from the rectus abdominis muscle.

EMG Data Analysis. The root mean square (rms) analysis was used to process the raw EMG data. After removing the largest and smallest values of 5 repetitions, the average of the remaining 3 rms data was used in statistical analysis. Delsys EMGworks Analysis software was used for all data analysis.

Research Ethics

The Hitit University non-interventional research ethics committee approved the study with its 19.09.2019 date and 2019-210 decision number.

Data Analysis

SPSS 25 was used for all statistical analysis. The normal distributions of data were controlled by using the Shapiro-Wilk test. Paired sample t-test was used the compare the RA muscle activity of exercise conditions. The statistical significance level was set to $p< 0.05$.

RESULTS

Table 1 shows muscle activity values of exercise conditions.

Table 1. Comparison of muscle activity expressed as μV (±SD) for rectus abdominis

Conditions	Rectus Abdominis (μV)	p
KTB	359.56 ± 160.50	0.018
STB	415.37 ± 185.63*	
Δ%	15.52	

Δ%: The percentage difference between conditions. *p<0.05 [Sig. (2 tailed)].

A Significant difference was found between the KTB and STB for the rectus abdominis ($t= -2.788$, $p=0.018$). The STB condition has significantly higher muscle activity for the rectus abdominis than the KTB.

DISCUSSION and CONCLUSION

The literature studies on muscle activation using EMG were commonly performed using different types of exercises named eccentric or concentric (Aspe & Swinton, 2014; Bird et al., 2006; Comfort et al., 2011; Escamilla et al., 2006; Youdas et al., 2008), and with load or without load (Bautista et al., 2020; Lawrence & Carlson, 2015) on different muscle groups. The present study is the first one to compare the RA muscle activity using EMG for the KTB and STB movements performed in different manners with oscillating and without oscillating. It was found that the RA muscle activity was significantly greater (% 15.52) during the STB than KTB movement (Table 1).

When investigating the literature studies related to the rectus abdominis muscle activation by applying different exercises, Gilleard and Brown (1994) compared the abdominal

muscle activity during the different leg lowering movements. They reported that greater abdominal muscle activity was produced in thigh unsupported exercise than supported exercise. In another study, Chan et al. (2020) evaluated abdominal muscle activity using the sahrmann five-level core stability test reported that abdominal muscle activity was higher when heels did not contact the ground in levels 3 and 5. Aspe and Swinton, (2014) compared the muscle activity between the back and overhead squat with different intensities. Besides they compared muscle activity during some isolated trunk exercises and squat exercises. They reported greater muscle activation in the rectus abdominis muscle in ski-tuck, front plank, and side plank exercises than in squat exercises with 90% of 3RM loads. Comfort et al. (2011) conducted a study of recreationally trained men, who performed dynamic, strength exercises, and 30 seconds isometric exercises. They stated that prone bridge movement that contracted isometrically, provided significantly greater rectus abdominis muscle activity compared to the superman movement and dynamic exercises. Comfort et al. (2011) concluded that while strengthening the trunk muscles in rehabilitation, it could be preferred to reasonably begin primarily with static exercises. In addition, they reported that isometric exercises such as prone bridge could provide adequate stimulation for the core muscles. In contrast to the studies (Aspe & Swinton, 2014; Comfort et al., 2011), Bird et al. (2006) stated that the external oblique and rectus abdominis were significantly less active during the Ab-Slide exercise performed as an eccentric than during the crunch exercise performed as a concentric and the crunch exercise could prefer for abdominal exercise. Luciano et al. (2020) compared the muscle activation of rectus femoris and rectus abdominis in sit-up and curl-up. They reported that rectus femoris and rectus abdominis co-activated more in Sit-up than in Curl-up. In another study that related the core muscle activation, Tahara et al. (2023) studied when performed with and without a foam roller, the immediate effects on the EMG activity of the core muscles. Their study findings showed that there were no found differences between the exercises. Morat et al. (2019) stated that the exercises including the hip drop, side plank, and suspended crunch provided muscle activations of 60% and higher in the muscle of serratus, muscle of obliquus externus abdominis. Kim and Park, (2020) reported that it could be an effective exercise method for increasing the muscle activity of the abdominis muscles to the hollowing technique in the angle between the ground and the humerus. Based on the literature studies and our results, it may be preferred to use strict and eccentric exercises to produce a greater level of muscle activity for the rectus abdominis musculature.

The findings of the present study demonstrated that the difference in RA muscle activity during the STB and KTB movements showcases the importance of the STB movement on the RA that revealed greater motor units' activation in a non-oscillation position. Consequently, the study finding appears that the same exercise while performing different forms may lead to different rates of motor unit activation in the same muscle group. In addition, the findings indicate that the STB should be used in traditional abdominal core training programs, due to providing more motor unit activation than the KTB on abdominal musculature. The decrease in RA muscle activation could be related to the acceleration caused by the KTB movement position, leading to result in an oscillation of mass during the KTB compared to the STB. According to the results of this study, STB was found to induce more RA muscle activity than KTB. Therefore, it could be suggested that athletes perform STB instead of KTB for RA muscle improvement.

Conflict of interests: The authors state that there is no conflict of interest.

Authors' Contribution: Study design EMA, BG; Data Collection EMA, BG; Statistical analysis EMA; Manuscript preparation EMA, BG, ED**.**

Information on Ethics Committee Permission

Committee: Hitit University Non-invasive Research Ethics Committee.

Date: 19.09.2019

Decision / Protocol Number: 2019-210

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