ACUTE EFFECTS OF DENTAL APPLIANCES ON UPPER AND LOWER ISOKINETIC MUSCLE FUNCTION

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The possibility that athletic performance can be affected by a person's jaw posture during the activity has been of interest to sports practitioners for many years. Using established elbow and knee flexion/extension testing protocols on a calibrated isokinetic dynamometer (Biodex System 2, Shirley, NY), this study examined selected muscle function characteristics in male NCAA II college football players (n=18) under test conditions in which they wore a professionally-fitted dental appliance (PowerPlus) designed for optimal maxilla-mandibular spacing, a common "boil-and-bite"-type mouth guard (Shock Dr.), and conditions in which they were instructed to have their teeth touch while keeping the jaws relaxed (Relax) or clenched (Clench) without wearing any oral appliances. Results indicated a significant improvement in total work (+9.8%), peak torque/body weight (+10.5%), and average power (+11.25%) for elbow flexion in the PowerPlus relative to the Relax condition. Similarly, knee flexion total work for the PowerPlus was significantly higher compared to both Relax and Clench test conditions.

KEY WORDS: strength, isokinetic, mouth guard.

INTRODUCTION: Strength and strength training are critical to performance in competitive sports. Many studies have been conducted that evaluate the effect jaw position may have on acute muscle strength. These studies have shown that subjects who suffer from temporomandibular pain dysfunction (TMD) or have a severe vertical dimension of occlusion (VDO) can benefit from wearing a Bite Elevating Appliance (BEA) (Abdallah, et al., 2004). One such appliance that has been studied in depth is the MORA. This device has shown to improve isometric strength when worn in athlete and non-athlete populations compared to a habitual occlusion and placebo appliance (Gelb, et al., 1995). The data has shown there is an optimal maxilla-mandibular spacing that can create maximum isometric strength (Chakfa, et al., 2002). Making the spacing larger or smaller can decrease a subject's strength. One study compared a BEA created for optimal spacing to a common mouth guard for American football players with TMD. The results showed that isometric strength was improved by using a common mouth guard and even more using the BEA (Abduljabbar, et al., 1997).

Unfortunately, BEA's have not proven effective in all studies. In particular, isokinetic strength has not proved to increase with the use of BEA's (Forgione, et al., 1991). These tests have been conducted at various speeds (60,120, and 240 °/s) without significant results. If BEA's can only improve isometric strength they will offer minimal benefit to athletes who rarely perform isometric tasks in competition. The goal of this study was to test the effect of selected oral appliances on isokinetic strength in athletes. The hypothesis is that wearing a BEA designed for optimal maxilla-mandibular spacing can increase isokinetic strength in an athlete population without screening for VDO. The BEA was compared to a common mouth guard in addition to no appliance conditions to determine if similar results could be obtained with a simple, off the shelf alternative.

METHODS: Bite Appliance Fitting: The effect of wearing the dental appliances on strength was tested in eighteen NCAA Division II American football athletes. The mean age of the subjects was 20 +/- 1.4 years. The subject's average height and weight was 1.87 +/- 0.07 m and 101.2 +/- 18.4 kg. The athletes were fitted for two mouth guards typically worn during sport and practice. One mouth guard was the commercially available Shock Doctor Pro (Plymouth, MN). These mouth guards were fitted according to the manufacturer's instructions, by heating in water and biting the appliance to fit each subject. The other mouth

guard was a PowerPlus (Traverse City, MI) mouth guard. This appliance can be customized in many ways. For the purpose of this study, lower dental impressions were taken, and the appliance was fabricated on a stone model for each test subject. The mouth guard was then custom-fitted by a dentist. The PowerPlus mouth guard is a BEA that is designed to optimize the non restrictive jaw position. Each subject's vertical dimension of occlusion was measured and the mouth guard thickness adjusted to create vertical dimension of occlusion of 19 mm.

Data Collection: The subjects participated in two different strength tests under four different conditions. The conditions included both mouth guards and two conditions without any dental appliance. These conditions required subjects to clench their teeth for one condition (clench) and to have their teeth touching while relaxing their jaw for the other condition (relax). Upper and lower body isokinetic tests were conducted on a Biodex System 2 (Shirley, NY). The subjects performed four sets for both tests, one for each condition. The order of the sets was randomized for each participant.
The tests were concentric-concentric tests at a velocity of 60°/s on the subjects' dominant side. The upper body test was an elbow flexion/extension, and the lower body exercise was knee extension/flexion. Prior to isokinetic exercise testing, each subject completed a standard warm-up protocol that consisted of a 5-min sub maximal upper or lower body cycle ergometry exercise at a moderate intensity. The Biodex device was calibrated before each day of testing and the device was warmed-up according to the manufacturer's instructions. The Biodex positioning was adjusted for each test subject to ensure proper alignment with joint position. Once the device was positioned properly, the subject was secured in place and allowed to familiarize themselves with the device and the exercise. They were instructed to perform the exercise motion without resistance to familiarize them with the range of motion and the device. The subjects performed a set of five repetitions for each of the conditions listed above. The subjects were given a three minute rest period between each of the sets. To diminish effects of position changes on results, the subjects remained in the Biodex chair with the restraints in place during the rest periods. here was no verbal encouragement provided during any of the testing, and the monitor of the Biodex was adjusted so that the test subjects could not observe their performance during testing. The results were not made available to the test subjects until all testing had been completed.

Data Analysis: Four variables were evaluated for the isokinetic tests: Peak Torque/Body Weight (PT/BW), Max Repetition Work (MRW), Total Work (TW), and Average Power (AP). Since the subjects varied considerably in stature and strength, the data was normalized using the relax condition before statistical analysis was conducted. The relaxed condition was considered the baseline, and was subtracted from all conditions. The other three conditions were evaluated as improvements or degradations from the relax condition.
The results were analyzed using SPSS 17.0 (Chicago, IL). MANOVA's were conducted for the upper and lower body isokinetic tests in flexion and extension. Bonferroni post hoc tests were conducted for any conditions that demonstrated a statistical significance ($p \leq 0.05$).

RESULTS: In extension, the isokinetic tests did not show statistical significance for any variables in either test. However, both tests had statistical significance in flexion (Table 1 and Table 2). The upper body tests showed that using the PowerPlus yielded significantly higher results than the relax condition for PT/BW, TW, and AP (p = 0.007, 0.02, and 0.011 respectively). The lower isokinetic tests showed that using the PowerPlus yielded significantly higher than the relax and the clench conditions for TW (p = 0.021 and 0.031 respectively).

Table 1 Upper Body Isokinetic Data Means

	Upper Body			
Condition	PT/BW (%)	RW (J)	TW (J)	AP (W)
Clench	1.69	3.99	25.58	3.59
PowerPlus	3.19†	8.30†	41.95†	8.30†
Shock Dr.	2.21	5.50	22.15	5.72
Relax	0.00†	0.00†	0.00†	0.00†

Results marked with † are statistically significant ($p \leq 0.05$)

Percent increases were calculated for the data that proved significantly different. Using the PowerPlus BEA showed mean improvements of 10.5%, 9.8%, and 11.2% from the relax condition in the upper body tests for PT/BW, TW, and AP respectively. The total work for the PowerPlus lower body tests was significantly improved from both the relaxed and the clenched conditions. It provided an increase of 16.8% and 16.0% from the relaxed and clenched conditions, respectively.

Table 2 Lower Body Isokinetic Data Means

	Lower Body			
Condition	PT/BW (%)	RW (J)	TW (J)	AP (W)
Clench	0.21	-0.62	5.02†	3.59
PowerPlus	6.54	20.03	113.40†	21.70
Shock Dr.	2.68	4.03	35.06	8.34
Relax	0.00	0.00	0.00†	0.00

Results marked with † are statistically significant ($p \leq 0.05$)

DISCUSSION: These results indicate using BEA devices can increase isokinetic strength in athletes without screening for severe VDO. This implies that an average athlete population could benefit from the device. Some subjects may observe a larger benefit due to their predisposition, but it appears there is a benefit to the general population. During the fitting of the BEA, the VDO was measured for each subject, and these measurements could be utilized to compare groups based on their VDO. The improvements in strength could be compared between large and small VDO groups to determine if there is a significant difference between the groups.

Future studies could examine the long term effects of BEA's on strength and performance. Athletes could be evaluated over the length of an off-season strength conditioning program. Strength improvements could be compared between subjects who are provided a BEA to wear during strength training to a control group participating in the same conditioning program. Other studies have required subjects to wear their BEA for a week before testing (Allen, et al., 1984). This study did not find any statistical significance, but week to week performance variability for test subjects could have diminished results.

The ultimate goal of improving an athlete's strength is to improve their sport-specific performance. One study examined a test more applicable to sports, the in-flight velocity of golf balls (Egret, et al., 2002). This study found that velocity increased and was more consistent with the BEA. Future studies should examine other sport-specific tests to determine if BEA's can improve performance. American football athletes could perform a battery of tests included in the NFL combine (40 yard dash, standing long jump, bench press, etc.).

CONCLUSION: These data indicate wearing dental appliances designed for optimal maxilla-mandibular spacing can improve isokinetic strength in flexion. Using the PowerPlus BEA provided improvements in both upper and lower body isokinetic flexion. These results differ from previous studies. Using the PowerPlus device provided statistically significant increases in three of the four variables evaluated (PT/BW, TW, and AP) compared to the relax condition in elbow flexion. It provided increases of 10.5%, 9.8%, and 11.2% for these variables respectively. In isokinetic knee flexion, the PowerPlus increased TW by 16.8% and 16.0% compared to the relaxed and clenched conditions.

These improvements were not present with a common mouth guard. These data show that an average athlete population can benefit from a specifically designed BEA, and that a common mouth guard does not provide the same benefit.

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