EFFECT OF A NEUROMUSCULAR DENTISTRY-DESIGNED MOUTHGUARD ON PEAK KNEE VALGUS MOMENTS DURING SINGLE LEG LANDING

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INTRODUCTION

Peak knee valgus moments (pKVM) have been identified as a potential risk factor for ACL injury. Recently, mouthguards developed using principles of neuromuscular dentistry have been touted as being able to enhance balance and strength by promoting optimal jaw alignment. A previous study observed increased vertical jump height when a neuromuscular-dentistry designed mouthguard was used [1]. If wearing such a mouthguard were to improve both balance and strength, it could lead to beneficial effects on dynamic knee loading. Given the prevalence [2], cost [3], and sequelae [4] of ACL injuries in sports where mouthguard use is common such as basketball, improvements in dynamic knee loading that reduce risk of ACL injury may be an important consideration. This study tested the hypothesis that wearing a custom neuromuscular dentistry-based mouthguard reduces pKVM in single-leg landing relative to a low-cost boil-and-bite mouthguard, or no mouthguard.

METHODS

Forty-six athletes (38M, 8F, 74.8±13.9kg, 1.75±0.09m) participated in this double-blind crossover study after providing IRB-approved informed consent. A priori sample size estimation indicated a desired population of 36 for an effect size of 0.25. Inclusion criteria included: (a) 2 or more years of current involvement in a designated sport, (b) an average of 3 or more training sessions per week in the last 3 months, (c) an average of 6 or more hours of total training time per week, (d) 1 or more instances of competition per year in the designated sport, (e) no current pain limiting athletic movement, and (f) no neck or jaw condition that would limit the ability to wear a mouthguard.

Three mouthguard conditions were utilized for the study: NDD - neuromuscular dentistry-designed lower-jaw mouthguard (Pure Power Mouthguard, Makkar Athletics, Inc.); BB - boil-and-bite lower-jaw mouthguard (Gravity 2 STC, Shock Doctor, Inc.); NO - no mouthguard. A fitting session for both mouthguards was performed first by a dentist experienced in fitting both types of mouthguards, followed by a single testing session several weeks later. Fitting for NDD involved 60 min. of transcutaneous electrical nerve stimulation (TENS) to induce jaw muscle relaxation. BB fitting was performed according to package directions.

Subjects performed 3 practice trials of single-leg landing on each leg. Then, for each mouthguard condition, subjects performed 4 test trials on each leg. The condition order was randomly assigned for each subject. Participants dropped off a 48-cm box with both feet, landing with a single leg on a force plate (Bertec, Inc.) and attempting to hold for 2s. An 8-camera optical motion analysis system (Vicon, Inc.) with retro-reflective markers placed on the pelvis and lateral knee, ankle, and foot was used to calculate net external pKVM during the 1st 100ms after foot strike (Nm/kg).

1061 out the 1104 single-leg landing trials collected from the 46 subjects contained usable data for the analysis. One subject only had usable data for the NDD condition, while another only had usable data for the NO condition. An additional 11 randomly-distributed trials were not usable due to marker gaps >100ms.

An unbalanced mixed-effects ANOVA including mouthguard, side, and mouthguard*side interaction as fixed effects was performed (ANOVAN, Matlab, MathWorks, Inc.), with post-hoc Tukey’s HSD comparisons to identify differences between the 3
mouthguard conditions and between sides (MULTCOMPARE, Matlab, MathWorks, Inc.). An
\textit{a priori} significance level of $\alpha=0.05$ was used for all tests.

**RESULTS AND DISCUSSION**

Mouthguard condition was a significant main effect ($p=0.0104$), as was side ($p=0.014$). Post-hoc analysis showed that pKVM was significantly lower for NDD than BB, but neither NDD nor BB was significantly different from NO (Figure 1). Participants displayed significantly lower pKVM on their left side than their right side (Figure 2). No significant interaction was observed between mouthguard and side ($p=0.0879$).

![Figure 1. Population marginal means for pKVM with 95% confidence intervals. [A] No Mouthguard (NO), Boil-and-Bite (BB), and Neuromuscular Dentistry-Designed (NDD) mouthguards. [B] Left and Right side landings.](image)

The NDD mouthguard appeared to influence neuromuscular control during the single-leg landing task by reducing pKVM relative to the boil-and-bite mouthguard. The reduction was relatively small between mouthguard conditions (6.4%, effect size = 0.15) compared to the previously observed reductions from neuromuscular training in pKVM during a double-leg drop-jump of 10-30% [5]. It should also be noted that the observed difference between BB and NDD was similar in magnitude to the difference between sides (4.4%, effect size = 0.10). Nevertheless, given that an increasing number of sports are requiring or strongly recommending mouthguards for participation, potential benefits from a more expensive mouthguard, such as a reduction in known biomechanical injury risk factors, may offset increased costs of the mouthguard.

The results of this study should be considered in light of its limitations. First, the single-leg landing test, while clinically relevant, may result in pKVM that is different from other activities such as cutting or stop-jumps. These more dynamic, sport-specific activities could result in a different relationship between the mouthguard conditions. Moreover, it remains unknown whether the results observed during a single testing session would change over time as the wearer grows accustomed to the different mouthguards. Lastly, the boil-and-bite mouthguard is “one size fits all,” which anecdotally resulted in a poor fit for some participants even after multiple attempts at re-fitting. Less than optimal fit in these participants could potentially have contributed to the observed effect on pKVM.

**CONCLUSIONS**

This study demonstrated a reduction in pKVM in subjects wearing a custom neuromuscular dentistry-designed lower-jaw mouthguard relative to a standard boil-and-bite lower-jaw mouthguard. Future prospective studies are needed to test the persistence of this phenomenon, whether the results carry over to mouthguards that provide upper-jaw dental protection, and whether these observed differences in pKVM lead to reduced injury rates.

**REFERENCES**


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