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Impacts of Non-Custom Mouthguards on Muscular Strength and Vertical Jump Height in Collegiate Athletes

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ABSTRACT

Objectives: To examine the impacts of non-custom mouthguards on muscular strength performance of the knee and shoulder joint, as well as jump height in collegiate athletes with no TMJ Disorder. Methods: Twenty-four student-athletes participated in the study. The participants divided into four groups randomly. Each group performed five tests under two conditions. The tests performed were knee flexion, knee extension, shoulder external rotation, and shoulder internal rotation at two different angular velocities, 60°/s and 180 °/s on a Biodex System 3 dynamometer, and a maximum vertical jump assessed using a Vertec apparatus. The test was performed under two conditions, with and without mouthguards. Results: Nine 4 x 2 mixed-model ANOVAs examined the effects of group and test on each measured variable. Mouthguard significantly improved the torque output in knee extension at 60º/s. No significant differences were found between group and bite condition for the internal/external rotation of the shoulder, and maximum vertical jump. Discussion: Mouthguard used has little effect on muscular strength for the knee and the shoulder, as well as on jump height. However, it is not known whether there’s an effect on additional joints in the kinetic chain of the body.

INTRODUCTION

It is recognized that the use of mouthguards for protection in sports is an important issue; several athletic organizations have adopted mandatory regulations for the utilization of this equipment during play, particularly football organizations such as the National Football League (NFL) and that of the National Collegiate Athletic Association (NCAA) [1, 2]. More specifically, Bailey et al. [3] mentioned recently that the NCAA requires the use of mouthguards in four sports (ice hockey, field hockey, football, lacrosse), and the American Dental Association (ADA) recommends the use of mouthguards in 29 sports. Although many athletes understand the idea that mouthguards should be worn for injury prevention of the mouth and surrounding tissues, relatively few individuals regularly wear a mouthguard during training and competition in which they are not mandated to wear one. These athletes cite reasons such as difficulty with conversation, discomfort, the sensation of vomiting, breathing difficulties, and an increased secretion of saliva [4]. Other reasons for the lack of mouthguard use included a concern that it may interfere with athletic performance [5]. In 2015, Bailey et al. [3] investigated whether the mouthguard influences performance during agility tests and concluded that this equipment negatively affected perceptions of breathability, comfort, and ability to communicate but have no negative impact on physiological function.

In an attempt to encourage the use of mouthguards, a number of studies have investigated the effects of mandibular positioning and the potential abilities to improve athletic performance. Mouthguards are essentially soft, oral equipment; therefore, the occlusion of the teeth is manipulated when it is placed into the mouth, as is with any type of oral equipment. Because of this, in addition to protecting the teeth to prevent tooth loss during a high-contact activity, they can also be used to reposition the mandible and change the articulation of the teeth. A complex relationship exists between the joint of the jaw and the muscles of the head and neck, as well as the entire body. Building upon this association, equipment that repositions the mandible can help reduce stress and tension in the muscles, improve abnormalities in body posture, and increase physiological and exercise performance [6]. These changes can be attributed to the fact that a mouthpiece acts as both a stabilizer and a shock absorber [1].

Early research into the study of mandibular adjustment to increase muscular strength included simple wax bite registrations. In a study, whose efforts were to obtain objective evidence that body muscular strength is correlated to posture and condition of the jaw, Smith [7] created wax bites for the ideal occlusal position for professional football participants. Comparing positions of the usual bite of the participants with the new position (using the wax bites) in tests of resistance strength of the forearm, revealed a significant difference of the arm's ability to resist downward movements. The same study further tested participants' strength using a Cybex II dynamometer and found a positive correlation between the use of wax bites to position the jaw and increase muscular strength [7].

Most research in the area of mandibular adjustment and its effects on muscular strength has used the Mandibular Orthopedic Repositioning Appliance (MORA). One study examined 20 undergraduate students to determine the effects of three different bite conditions a MORA, a placebo, and no appliance on shoulder strength [8]. The authors conducted shoulder strength tests and found an increase in shoulder strength in comparing the MORA to the other two bite conditions. Another experiment found similar results when examining male varsity athletes and the effects of MORA on both shoulder strength (abduction and adduction) and knee flexion and extension [9]. They concluded that mandibular position might affect appendage muscular strength. Bates and Atkinson [10] showed that wearing a MORA significantly increased muscle strength during vertical jump and grip tests but not while participants performed maximum hip sled and bench press. More recently, Lee et al. [11] concluded that forearm muscles activation and grasping power significantly increase when wearing the MORA and believed that occlusal appliances might improve the function of the forearm because it activates the function of the masseter muscle. Grosdent et al. [12] also observed an immediate and significant alteration of knee eccentric muscle performance at 30º/s with female participants without temporomandibular joint dysfunction while performing isokinetic tests wearing a custom-made equipment.

Although this information exists on individually fitted equipment, the literature lacks investigation into the effects of non-fitted mouthguards on strength. Therefore, the purpose of this investigation was to carefully examine the impacts of a non-custom mouthguard on knee flexion and extension torque, shoulder external and internal rotation torque, and the effect of such mouthguards on maximal vertical jump height.

MATERIALS AND METHODS

Twenty-four students athletes, 8 males, and 16 females, aged 18 or older, participated in the study.

Each participant had completed a profile questionnaire. Exclusion criteria were past jaw injuries and/or diagnosed Temporo Mandibular Disorder (TMD). Non-fitted SafeTgard (Wheat Ridge, Colorado, USA) upper and double mouthguards were used during this study.

A Biodex System 3 dynamometer, was used to measure torque output at the shoulder and knee. It is considered a reliable and valid apparatus for torque measurement at all velocities, except those that are 300 °/s and above [13]. The Vertec Jump Height Test apparatus was used to measure maximal jump height; the Vertec has been shown to be a valid and reliable apparatus [14].

The participants were divided into four groups based on the order in which they signed up for the study. The two first groups used only the upper mouthguards whereas the two other groups used a double mouthguard. The order between with and without mouthguards was randomized. Each protocol was assessed in six sets (three sets with the mouthguard and three set without mouthguard) of five repetitions each with one-minute rest in between each set. For each participant, vertical jump height was assessed after performing isokinetic testing of both the knee and shoulder, at the two different velocities. The order in which the joints and the velocities at which those joints were tested was random.

Isokinetic knee flexion/extension and Isokinetic shoulder external/internal rotations data were collected at both 60 °/s and 180 °/s during concentric concentrations. Diagonal straps were placed across the trunk, one over each shoulder, as well as across the upper thigh of the left legs, to ensure that the motion was restricted to the tested limb and that leveraging actions would be minimized from other parts of the body. The chair of the dynamometer was adjusted to each of the participant's dimensions. Each repetition had the participants move through the full available range of motion of the joint while in the chair.

For the vertical jump test, the participant first had his or her standing height with one arm fully extended upward taken. The participant then, from a squatting position, jumped off the ground with two feet and touched the highest possible vane. The difference between standing height and jumping height was then measured in centimeters. This was repeated six times total, three times with mouthguard and three times without mouthguard.

Peak torque values for each of the sets were obtained for both the knee extension and flexion, and shoulder external and internal rotations in the two different velocities. Peak torque was recorded in foot-pounds and later converted into Newton meters (Nm). The average of the isokinetic test results and the vertical jump trials, with and without the mouthguard, were compared for each participant, and furthermore within and between groups.

All statistical tests were analyzed by Statistical Package for Social Sciences (SPSS) version 22.0 (SPSS Inc., Chicago, IL, USA). 4 x 2 between-within mixed-design ANOVAs were completed for each dependent variable at each velocity, for each joint, with an additional one done for jump height. This allowed for the comparison of the changes between bite condition (mouthguard or no mouthguard) for each group, as well as a comparison amongst the four different groups.

RESULTS

A significant relationship was found between group and bite condition for the peak torque values of the knee extension at 60 °/s ($F(3,20) = 4.391$, $p < .05$) (Table 1). Upon examination of the data, Groups 1, 2, and 3 showed significant peak knee extension torque improvements for the knee when using the mouthguard. In addition, the main effect for bite condition was also significant ($F(1,20) = 10.461$, $p < .05$). The main effect for group was not significant ($F(3,20) = 1.059$, $p > .05$).

Table 1 - Descriptive Statistics – Peak torque during the knee flexion/extension at two different velocities (60º/s & 180º/s) for the 4 groups tested with and without mouthguard

		60/60		180/180	
Variable	Group	Mean	SD	Mean	SD
Peak Torque Away (Nm) – No Mouthguard	1	92.64	28.45	69.89	17.38
	2	144.53	69.57	88.64	57.39
	3	110.72	46.56	38.51	18.29
	4	119.52	41.11	70.14	25.01
Peak Torque Away (Nm) – Mouthguard	1	114.25	36.62	93.58	28.49
	2	151.31	75.59	91.75	51.70
	3	126.42	60.89	63.11	29.77
	4	113.01	41.37	65.21	33.88
Peak Torque Towards (Nm) – No Mouthguard	1	70.14	22.80	78.57	37.31
	2	96.02	32.28	54.33	32.36
	3	85.46	18.32	34.51	8.08
	4	91.72	36.01	52.95	31.77
Peak Torque Towards (Nm) – Mouthguard	1	88.64	18.43	101.75	89.81
	2	102.07	30.91	72.47	30.47
	3	96.40	19.59	58.00	18.64
	4	86.91	38.10	53.69	34.64

Note G1 & G2 – Upper mouthguard groups; G3 & G4 – Double mouthguard groups.

No significant differences were found between group and bite condition for the internal/external rotation of the shoulder and the knee flexion at both velocities. Moreover, no significant difference in knee extension torque was found at the velocity of 180 °/s (Table 2). Jump height was overall improved, but not enough to be considered significant (Table 3).

Table 2 - Descriptive Statistics - Peak torque during the shoulder external/internal rotation at two different velocities (60°/s & 180°/s) for the 4 groups tested with and without mouthguard

		60/60		180/180	
Variable	Group	Mean	SD	Mean	SD
Peak Torque Away (Nm) – No Mouthguard	1	13.53	5.36	20.41	6.68
	2	25.31	11.58	25.80	10.85
	3	19.63	10.55	19.96	11.62
	4	14.44	5.03	20.24	5.10
Peak Torque Away (Nm) – Mouthguard	1	13.40	3.08	19.35	6.83
	2	24.72	12.41	26.57	11.48
	3	17.79	6.01	22.33	10.10
	4	15.21	4.42	22.60	5.71
Peak Torque Towards (Nm) – No Mouthguard	1	27.43	6.91	28.27	6.58
	2	55.05	24.80	46.71	16.76
	3	39.48	20.57	26.21	18.37
	4	33.39	7.55	31.28	9.98
Peak Torque Towards (Nm) – Mouthguard	1	29.06	4.88	31.21	5.18
	2	57.42	23.51	46.41	10.94
	3	40.92	18.36	32.36	17.64
	4	34.06	8.18	29.99	13.02

Note G1 & G2 – Upper mouthguard groups; G3 & G4 – Double mouthguard groups.

Table 3 - Descriptive Statistics – Jump Height for the 4 groups tested with and without mouthguard

Variable	Group	Mean	SD
Height Difference (cm) – No Mouthguard	1	40.12	4.68
	2	59.97	11.27
	3	44.80	11.34
	4	46.52	13.94
Height Difference (cm) – Mouthguard	1	42.68	5.82
	2	64.63	15.25
	3	48.29	14.18
	4	47.42	14.75

Note G1 & G2 – Upper mouthguard groups; G3 & G4 – Double mouthguard groups.

DISCUSSION

The results of this study support in part previous studies in the field of mandibular adjustment and strength changes in athletes, that shows improvement in strength when using a MORA with athletes not inflicted with TMD [8]. When studies used wax bite registrations, improvements were also found for muscular strength performances [7,9].

While executing the study, the researcher found many participants with "open bites" – a common display in asymptomatic TMD patients. These participants were not excluded from the study. The fact that these participants were approved for participation may have affected the data. In a previous study, the authors concluded that athletes with an internal derangement of the Temporo Mandibular Joint (TMJ) should not wear "thick" mouthguards, and attention should be made to the placement of the mouthguard [16]; in fact, this particular study found that mouthguards should only be placed after examining the patient including completing an MRI on the joint in order to place the mouthguard properly in its correct "setting" in the mouth.

In looking at the data for the knee and jump height tests, there were indeed improvements; however, most of these improvements were not high enough to be determined significant at the 0.05 level. In terms of the shoulder, there seems to have been no detriment or improvement in the isokinetic ability tested. This directs the authors to believe that there is a potential to see improvements in muscle strength and jump height. The lack of significance may have been due to many possible reasons. For one, in that the shoulder joint seems to have been unaffected by the mouthguards which were tested, while the knee was slightly improved, leads the researcher to suggest a reasoning as to why such results occur. The knee is a more stable, weight-bearing joint with two degrees of freedom, while the shoulder has much less restriction at three degrees of freedom and is not weight-bearing should be considered as a contributing factor. The stability and structure of the knee allow for stronger ligaments and therefore a stronger joint structure; this may contribute to a stronger "pulley" in the kinetic chain in terms of the effect of placing a mouthpiece in the oral cavity and testing its effect on the full body.

Secondly, there was little control over the size and construction of the mouthguard. Although the study intended to test non-custom, stock mouthguards, which was the same for all participants who used the same mouthguard type, there was little ability to account for the effects by the fact that each person's bite is unique. The mouthguard may not have been the correct size for all participants. For example, one participant complained that the mouthguard was too big for her mouth, while another participant complained of difficulty breathing while wearing the mouthguard. In order to maintain control over the mouthguard in its non-custom form, modifications to mouthguards – such as cutting off some length from the ends in order to make a smaller size – were not made. One must also consider that a mouthguard that may have been too small would have been impossible to alter in a non-dental laboratory setting, therefore supporting the idea that the equipment should not have been altered, despite discomfort experienced by some participants. In order to account for those participants whom the mouthguard did not fit properly, it may be necessary to perform several adjustments to the presented methodology. While keeping with the purpose of testing affordable non-custom mouthguards, it would be interesting to see the effects of a mouthguard that is the same in its character of being a stock mouthguard but is available in more sizes, thicknesses (to account for deeper bites), and positioning.

Further improvements for this study include testing other joints of the body, including the hip, elbow, and ankle should be considered when examining the effects of bite condition on muscular strength. By examining such joints as these, the ability to infer the results to a wider range of athletes may be possible. In addition, another test that should be considered is Electromyography (EMG). Possessing such data would enable the researcher to provide the activity within the individual muscles, as opposed to the muscle groups that conduct the specific action on the joints.

CONCLUSION

According to the results, mouthguard used has little effect on muscular strength for the knee and the shoulder, as well as on jump height. However, it is not known whether there is an effect on additional joints that all play a part in the kinetic chain of the body. Although there is little support of significant improvements in this study, this may make a difference for some athletes, especially those to which knee extension is often performed (i.e., rowing, and any sport that involves running). Regardless, it is the researcher's opinion that mouthguards, whether upper or double in type, should still be used as a means of protection for the teeth and mouth during athletic activity, particularly while playing contact sports.

DISCLAIMER STATEMENTS

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Conflicts of interest The author declare that they have no conflict of interest. The authors have no professional relationships with any companies or manufacturers identified in this study.

Ethics Approval The current study was performed at Barry University, with the approval of the Institutional Review Board (No.090910).

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