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The effects of mouthguards on the athletic ability of professional golfers

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Abstract – The purpose of this study was to determine the effect of stabilization splints and mouthguards on the athletic ability of professional golfers. For this study, eight professional golfers with a mean age of 20.5 were selected. These participants performed four trials of 10 driver swings and 10 putts with or without a stabilization splint (control group) or mouthguard. For the 4th trial, the splints were adjusted using a simple blind test so that the participants were unaware of the unilateral molar contact. The drive distance, club head speed, initial ball speed, and putting accuracy were compared and analyzed before and after the application of equal bilateral molar occlusion. When the bilateral molar occlusion was applied using a mouthguard or stabilization splint, the club head speed and driving distance in the presence of the oral appliances were significantly increased compared with those without the presence of either appliance ($P < 0.05$). Alternatively, the initial ball speed and putting accuracy in the presence of these appliances were increased compared with those without the presence of an appliance; however, this effect was not statistically significant. When the mouthguards or stabilization splints were adjusted to result in unilateral molar occlusion, the club head speed and driving distance in the presence of the appliances were significantly decreased compared with those that were obtained without these appliances ($P < 0.05$). The initial ball speed and the putting accuracy were not affected by the use of the appliances. No difference was observed in the effectiveness of the stabilization splint and mouthguard when bilateral molar occlusion was performed. The occlusion stability that results from stabilization splints and mouthguards is thought to increase the club head speed and driving distance in professional golf players.

Recently, there has been an increased interest in sports dentistry in Korea. As a result, various types of research articles have been published. A portion of this research involves sports-related trauma prevention and focuses on the effects of mouthguards on maxillofacial, head and neck trauma in physical contact sports. Cephalometric radiography data from football players who wore mouthguards have been reported on the reposition of anatomic structures (including the condyles and cervical vertebrae) and showed a decreased level of head and neck damage in those players who wore the mouthguards compared with those who did not (1). Moreover, many authors have reported that mouthguards may effectively prevent head and neck injury during sports activities, and it is compulsory to wear mouthguards in many physical contact sports, such as football and boxing (2–4).

Another research in sports dentistry described the effects of maxillofacial changes, such as mandible repositioning on overall athletic ability, an effect that may be primarily caused by changes in balance and muscular strength (3–5). Maxillofacial muscles have a complex relationship with the entire body, and therefore, more effective physiologic states can be attained by correcting inappropriate relationships between the maxilla and mandible (6–8). The terminology mandibular orthopedic repositioning appliance (MORA) has been used to describe a device that makes such a correction (9, 10). MORAs have been reported to significantly increase the participants' sense of balance strength in the leg and arm muscles (11–13).

Athletes who were equipped with mouthguards or stabilization splints exhibited an increased muscular strength and sense of balance (14, 15). Experiments on golfers were performed and increases in the driving distance and initial ball speed were reported (16). When the increase in the driving distance was greater than the increase in the initial ball speed, it was assumed that these increases were the result of accurate impact with the ball that was caused by increased mental concentration at the moment of impact. It could therefore be expected that stabilization splints would also positively affect putting, which requires concentration. The purpose of the drive in golf is to achieve the required driving distance by transferring as much momentum as possible to the ball. This transfer of momentum is achieved by the continuous and systematic actions of various parts of body (17). Therefore, muscular strength is a significant factor in improving one's driving distance and initial ball speed. However, in addition to muscular strength, driving distance can vary with the projection angle that is formed by the impact angle, initial speed, angular speed, angular speed of the hands, swing duration, and the center of body mass at the moment of impact among other variables (17). Therefore, a more sophisticated experimental design is required for the accurate analysis of the driving distance, including the measurement of the club head speed, to detect any improvement in muscular strength and to analyze the body's center of mass. These determinations can be made using three-dimensional video technologies and high-speed cameras. Studies using double-blind tests claimed that the effects of splints are caused by the placebo effect, and it was suggested that the use of MORA does not increase muscular strength (18, 19).

This study addresses the effects of the use of mouthguards on the athletic ability of professional golf players. The null hypothesis to be tested was that there were no significant differences in the effectiveness of the stabilization splint and mouthguards on the athletic ability of professional golfers. Active professional golf players participated in the experiment, and the control groups wore stabilization splints. Using a single-blind test for the equal bilateral and unilateral molar occlusions, the driving distance, club head speed, initial ball speed, and putting accuracy were compared before and during wearing the splint.

Materials and methods

Materials

Five male and three female students were selected from the Korean professional golf players who were attending the Kyung Hee University. The participants had a mean age of 20.5 years and no orthopedical or otolaryngological diseases that influenced their sense of balance. As determined by the results of an oral examination, a temporomandibular disorder examination, a diagnostic model examination, and temporomandibular joint radiography, no examinee exhibited a temporomandibular disorder. All participants gave their informed consent, and the study was approved by the Ethics Committee of Kyung Hee University.

Methods

Upper arch splints and mouthguards were fabricated on a semi-adjustable articulator (Hanau™ Modular Articulator System; Whip Mix Co., Exeter, KY, USA), and intraoral occlusal adjustments were performed (20). The accuracies of the driver swing and putting were measured.

Mouthguard fabrication

Impressions of the upper and lower dentition of the examinees were taken using irreversible hydrocolloid impression material (Aroma Fine DF III; GC Co., Tokyo, Japan), and definitive casts (GC Fujirock EP, GC Co., Tokyo, Japan) were produced using thermoforming blanks made of ethylene vinyl acetate copolymer sheet (Drufosoft®; Dreve Dentamid GmbH., Unna, Germany) and Drufomat II (Dreve Dentamid GmbH) to be of 2 mm thickness in the posterior teeth after occlusal adjustment (2).

Stabilization splint fabrication

The maxillary casts were mounted on a semi-adjustable articulator with a facebow (Hanau™ Spring-Bow; Whip Mix Co.). After the centric relation registration using bite registration material, (Aluwax; Aluwax Dental Products Co., Allendale, MI, USA), the mandibular casts were then mounted. Arbitrary dots were marked on the attached gingiva areas of the left canine and first premolar of the maxillary and mandibular casts. The incisal pin of the articulator was then elevated such that the distance between the dots was 2 mm. A wax sheet was adapted on the maxillary cast using baseplate wax (Kemdent modeling wax; Associated Dental Products Ltd., Wiltshire, UK). All the teeth contacted equally at maximal intercuspal position, and for the left and right lateral movements, six anterior teeth were observed to be equally guided. The casts with the waxed splints were flasked and fabricated using clear orthodontic resin (Dentsply Caulk, Milford, DE, USA) and were fitted in the examinee's mouth. Occlusal adjustments were then performed on the articulator and then intraorally.

Measurements of the driver swing and putting accuracy

The Golf Achiever II (Focaltron Co. Ltd., Sunnyvale, CA, USA) was used to measure the club head speed during the driver swing, the initial ball speed, and the driving distance. For the measurements of the putting accuracy, the examinees putted 5 m from the cup, and the distance between the center of the ball and the center of cup was measured after the completion of the putt. A shorter distance was regarded as a higher putting accuracy.

One trial consisted of 10 driver swings and 10 putts with a stabilizing splint, with a mouthguard, and with neither oral appliance. Each trial was performed on the same day, and four trials were performed in total. Because swing results may be influenced by the sequence in which the oral appliances were used, the testing sequences were varied. One week of rest was provided between each test day (Table 1). For the 4th trial, a single-blind test was used to eliminate any psychological effects. Specifically, the 1st through 3rd trials were performed with bilateral posterior occlusal contacts. For the 4th trial, the oral appliance was adjusted to have unilateral posterior occlusal contacts that were undetectable to the examinee.

Statistics analyses

The statistics analyses were performed using the computer statistical analysis program SPSS 12.0 (SPSS Inc., Chicago, IL, USA). The driver club head speed, initial ball speed, driving distance, and putting accuracy were compared using paired *t*-tests. The conditions with either

Table 1. Experiment schedules

Trials	Testing sequence
1st	Without appliance → With stabilization splint → With mouthguard
2nd	With stabilization splint → With mouthguard → Without appliance
3rd	With mouthguard → With stabilization splint → With mouthguard
4th	Without appliance → With stabilization splint → With mouthguard

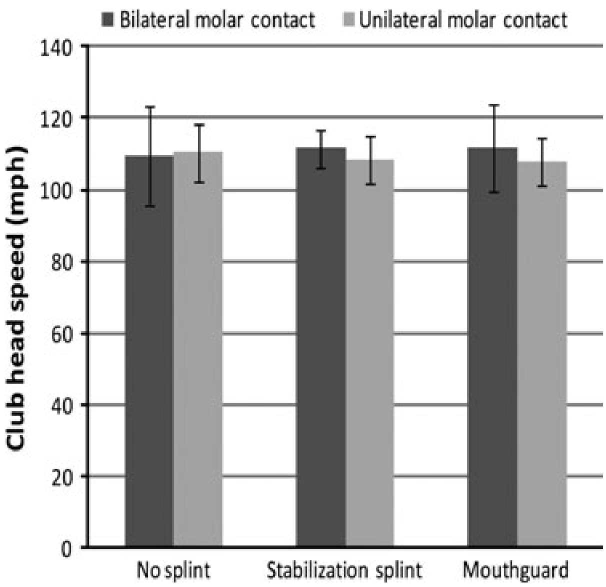

Fig. 1. Mean values of club head speed at bilateral and unilateral molar occlusion.

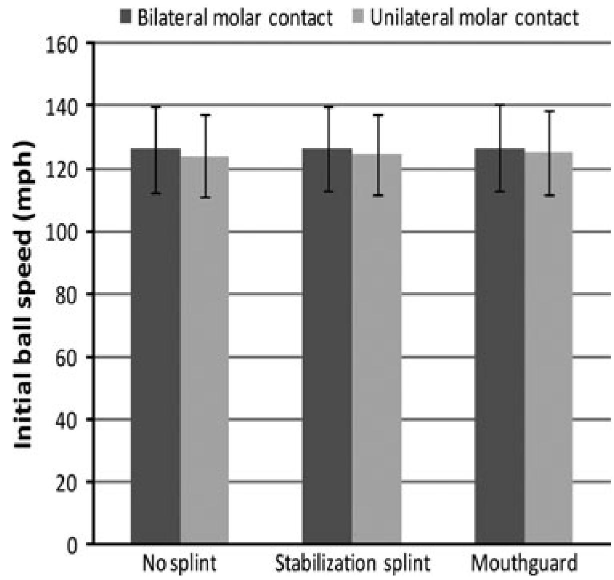

Fig. 2. Mean values of initial ball speed at bilateral and unilateral molar occlusion.

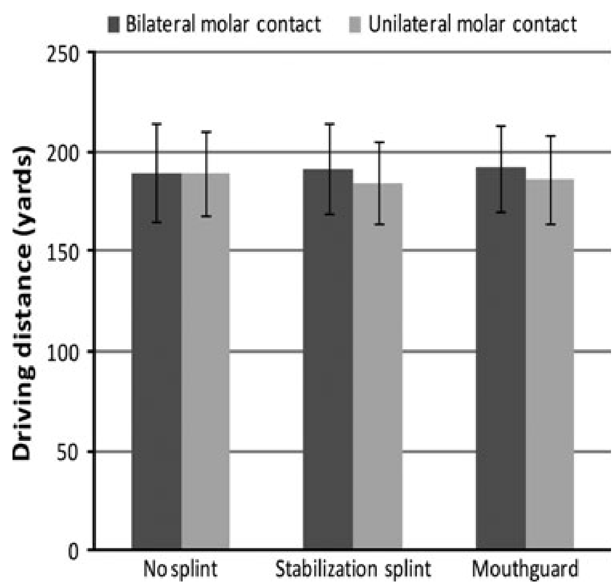

Fig. 3. Mean values of driving distance at bilateral and unilateral molar occlusion.

oral appliance which were adjusted to bilateral molar occlusion or unilateral molar occlusion were compared with the conditions without an oral appliance. Significance was defined at the 5% level. The maxima and minima were excluded from the 10 swings and 10 putts, and as a result, eight values were tested.

Results

Bilateral posterior occlusal contacts

The mean club head speed was 109.49 mph without the presence of either oral appliance. However, with a stabilizing splint, this value significantly increased to 111.54 mph, and the club speed increased to 111.77 mph ($P < 0.05$) with a mouthguard. The driving distance was 189.43 yards without the presence of either oral appliance. However, the driving distance significantly increased to 191.81 yards with a stabilizing splint, and this distance increased to 191.83 yards ($P < 0.05$) with the use of mouthguards. The initial ball speed and putting accuracy increased with the use of the oral appliances; however, these results did not show statistical significance (Table 2, Fig. 1–4).

Unilateral posterior occlusal contacts

The mean club head speed was 110.47 mph without the presence of either appliance but significantly decreased to 108.28 mph with the use of a stabilizing splint and decreased to 107.73 mph with a mouthguard ($P < 0.05$). The driving distance was 189.39 yards without the use of either oral appliance but significantly decreased to 184.61 yards with a stabilizing splint and to 186.17 yards with a mouthguard ($P < 0.05$). The initial ball speed and putting were not significantly different between the groups that used either oral appliance and those that did not (Table 3, Figs 1–4).

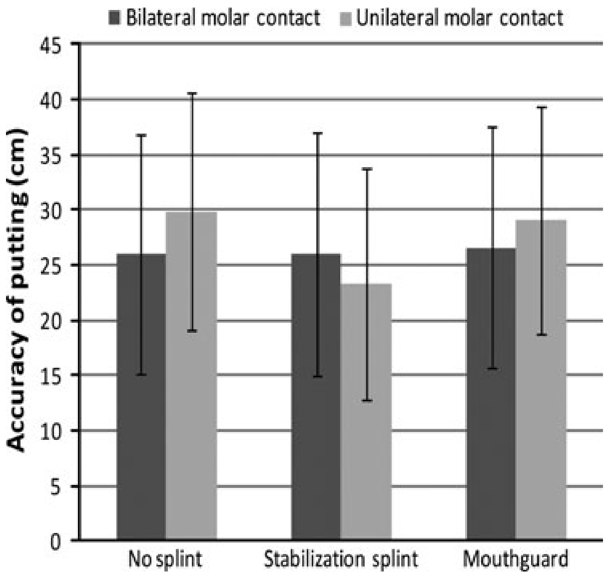

Fig. 4. Mean values of accuracy of putting at bilateral and unilateral molar occlusion.

Discussion

Stable occlusal contact is a basic requirement of oral functions, such as mastication, and plays an important role in the stabilization of the condyle and the neuromuscular system. Numerous articles have been published that demonstrate the correlation between occlusion and the temporomandibular joint disorders. Furthermore, many studies focus on the relationship between occlusion and whole body functions. Improvement of systemic athletic ability was reported with the use of MORA and mouthguards (1, 4–10, 12, 13). Mandibular repositioning because of an MORA induced increased muscular strength and muscular efficiency (21). Application of a stabilization splint with an occlusal vertical dimension (OVD) of 2 and 3.5 mm resulted in a significant increase in isokinetic muscular strength (22, 23). Thus, stabilization splints and mouthguards were designed with 2 mm of OVD elevation in this article. With equal bilateral posterior occlusal contact, the club head speed was significantly increased ($P < 0.05$). The club head speed is closely related to the strength of the leg and arm muscles, especially the muscular activation of the erector spinae muscles, the left external oblique muscle of the abdomen, the left rectus femoris muscle, and the left trapezius muscle. Therefore, additional tests using EMG measurements of each body part may be required to detect the muscle that is exhibiting increased strength (23).

The initial ball speeds and postures of golf players with or without an MORA have been analyzed. The initial ball speed increased significantly and was more consistent with an MORA but that there was no difference in posture (16). In this study, however, equal bilateral posterior occlusal contact using a stabilization splint or mouthguard resulted in an increased driving distance and initial ball speed; however, only the driving distance was significantly increased. The driving distance depends on the club head speed, elasticity of the shaft, uncocking velocity, projection angle to the ball at the moment of impact, and the initial ball speed among other factors. At the moment of the effective transfer of these kinetic variables of the golfer's body to the club head, achieving minimal positional change relative to the body's center of mass can increase driving distance. Therefore, significant increases in the driving distance in the absence of significant increases in the initial ball speed result from an increase in the club head speed,

Table 2. Mean values of the club head speed (CHS), initial ball speed (IBS), driving distance (DD), and accuracy of putting (AP) at bilateral molar contact

	No splint		Stabilization splint			Mouthguard		
	M	SD	M	SD	*P*-value	M	SD	*P*-value
CHS (mph)	109.49	13.82	111.54	5.15	0.035*	111.77	12.20	0.026*
IBS (mph)	126.26	13.83	126.29	13.34	0.942	126.67	13.78	0.421
DD (yards)	189.43	24.75	191.81	22.23	0.029*	191.83	21.79	0.022*
AP (cm)	26.02	10.87	26.03	10.99	0.997	26.61	10.93	0.818

*significantly different ($P < 0.05$).

Table 3. Mean values of the club head speed (CHS), initial ball speed (IBS), driving distance (DD), and accuracy of putting (AP) when using unilateral molar occlusion

	No splint		Stabilization splint			Mouthguard		
	M	SD	M	SD	*P*-value	M	SD	*P*-value
CHS (mph)	110.47	8.07	108.28	6.44	0.008*	107.73	6.43	0.008*
IBS (mph)	124.17	13.41	124.48	12.93	0.627	125.39	13.42	0.060
DD (yards)	189.39	21.23	184.61	20.57	0.000*	186.17	22.26	0.023*
AP (cm)	29.84	10.77	23.27	10.5	0.137	29.02	10.3	0.864

*Significantly different ($P < 0.05$).

which indicates an increase in muscular strength and impact accuracy (24).

Postural imbalance may be corrected by improving incomplete occlusion (25). Also, change of the mandibular position may affect the postural stability (26). In a golf swing, the rotating club head moves in a circular track with the axis of the body as the center, and putting demands concentration, accuracy and a sense of balance. In this study, putting accuracy was measured to determine whether the stabilization splints or mouthguards increased postural balance and concentration; however, the use of an oral appliance did not cause a significant effect on putting accuracy when compared with putting without an appliance.

The balance of the appliance has been considered important to increased muscular strength when wearing an MORA (14, 15). The effect of occlusal contact and balance on brain waves has been studied, and a relationship between the balance of the occlusal contact and the leg and arm muscles during the use of a stabilization splint was reported (27). Muscular strength after artificially inducing an occlusal contact imbalance in a stabilization splint was examined. It was reported that the muscular strength significantly decreased only in cases in which the posterior teeth contacted with each other unilaterally (28). In this study, to determine whether the occlusal contact pattern affects a golf player's athletic ability, swing and putting tests were performed after an adjustment of the stabilization splint and mouthguard to such that the posterior teeth contact each other unilaterally. In these experiments, a single-blind test was used so that the examinee could not detect that the appliance was adjusted, which eliminated the potentially interfering psychological effects. Following the unilateral occlusion, the club head speed and driving distance significantly decreased; however, the initial ball speed and putting accuracy did not exhibit significant differences. Therefore, stable occlusal contact may affect the muscular strength of the legs and arms (29).

Clearly, further study with sufficient sample size and more objective analysis or control of the occlusion is indicated. Within the limitations of this study, it can be concluded that occlusal stabilization using stabilization splints may improve a golfer's club head speed and driving distance.

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