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# EFFECT OF PROTECTIVE MOUTHGUARD USE ON EXERCISE PERFORMANCE PARAMETERS IN TAEKWONDO

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**Abstract:**
**Purpose:** This study investigates the effect of the use of specially designed protective mouthguards on agility, balance, flexibility, reaction time, and handgrip strength parameters from exercise performance parameters in taekwondo players. **Methods:** Thirty-seven athletes between the ages of 18 and 40 participated voluntarily. The study was conducted at the Alanya Budo Taekwondo Sports Club. Measurements were taken with and without the mouthguard, and conducted at least one day apart. Agility T-Test, flexibility Sit and Reach Test, balance Flamingo and Y Balance Test, reaction time Nelson-Hand Reaction Test, grip strength hand dynamometer evaluated. **Results:** There was no significant difference in the parameters of agility, flexibility, balance, reaction time, roasting power with and without a protective mouthpiece ($p>0.05$). In this study, while the positive effect of the personally designed mouth protector on performance was not observed, no negative effect was seen at the same time. **Conclusion:** The use of mouth protectors should be recommended, and the use should be increased because it reduces the severity of the traumas from the orofacial region.

**Keywords:** adults, athletes, martial arts, mouth protectors, hand strength

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## 1. Literature Review

Taekwondo is a competitive sport involving mutual attacks. In sports, a force of collision exceeding the physical resistance of the athlete results in trauma (Meeuwisse *et al.*, 2007). To minimize such trauma, athletes use mouth guards. The most effective way to reduce injuries of the maxillofacial region in sports is to minimize the force of impact that the athlete sustains. This can be achieved by using custom-made mouth guards appropriate for the type of sport practiced (Takeda *et al.*, 2004). The shouting sound called 'Kiai' uttered by athletes during attack and defense movements is considered an important part of mental and physical concentration in competitions. However, using a mouth guard may be a hindrance during shouting (Tulunoglu & Ozbek, 2006).

Many authors have reported that wearing a mouth guard in full-, limited- or non-contact sports improves exercise and sports performance beyond simple protection (Balanoff, 2009; Dunn-Lewis *et al.*, 2012). Use of a customized bite-aligning mouth guard has been reported to potentially improve exercise and sports performance by reducing cortisol concentration (Garner *et al.*, 2011), providing optimal temporomandibular joint (TMJ) alignment (Balanoff, 2009) and improving airway patency (Garner & McDivitt, 2009). Mouth guard use was reported to reduce mental and physical stressors and provide increased air intake to improve performance (Drum *et al.*, 2016).

In contrast to studies that advocate the performance-enhancing effects of mouth guards, many researchers have reported that exercising with a custom-made mouth guard, compared to exercising without it, does not affect athletic performance. For instance, a randomized repeated measures study conducted by Cetin *et al.* (2009) with taekwondo athletes found no difference between the groups in terms of strength, speed and anaerobic performance. Likewise, Kececi *et al.* (2005) evaluated aerobic performance in taekwondo athletes with and without a mouth guard and found no difference between the groups.

Previous studies have assessed strength, speed, anaerobic and aerobic performance in taekwondo athletes with and without a mouth guard. When the literature is examined, many studies have been conducted to see the effect of mouth guard use on performance, but the results have been different. In this study, the question of what effect the use of mouthguards has on the performance of taekwondo athletes was investigated. The present study sought to investigate the effect of custom-made mouth guards on certain exercise performance parameters, including agility, flexibility, balance, reaction time and grip strength among taekwondo athletes.

### 1.1 Hypotheses of the Study

**H0:** Use of a mouth guard by taekwondo athletes does not affect exercise performance parameters.

**H1:** Use of a mouth guard by taekwondo athletes affects exercise performance parameters.

## 2. Material and Methods

The sample size was calculated using GPower analysis. With an effect size of 0.15% and a statistical power of 80.2%, the calculation yielded a minimum sample size of 36 subjects.

The study enrolled 37 volunteering athletes affiliated with Alanya Budo Taekwondo Sports Club who had been practicing taekwondo for at least six months and had no systemic disorder. Ethics committee approval for the study was obtained from Alanya Alaaddin Keykubat University Clinical Research Ethics Committee. Athletes included in the study were those who used custom-made mouth guards. The athletes were informed about the study and asked to sign a voluntary consent form.

The study included athletes between 18-40 years of age who had been practicing taekwondo for at least six months and had a yellow-green belt and above. Exclusion criteria were: wearing braces, presence of systemic diseases, sports injuries due to competition or training, and pain complaints.

The sociodemographic characteristics of the participants were recorded, and athletes were first tested for exercise performance without a mouth guard. The following day, the athletes underwent the same tests without custom-made mouth guards.

Characteristics of the athletes were collected using a socio-demographic form and included sex, age, height, weight, body mass index (BMI), belt rank, length of practice, chronic disease status, medication status, marital status, and practice of any other sport. Agility; athletes were assessed for speed, change of direction and agility parameters using the T-Test. This test uses four cones and a stopwatch. Four cones are placed on a track at certain distances (Pauole *et al.*, 2000). The athlete changes direction by running to the right, left and backwards. It involves subjects changing direction twice, at 90° and 180° and a total displacement of 40 meters. The time of completion of the track in seconds is measured using a stopwatch. The athletes performed three maximal repetitions with complete rest, and the best score was recorded.

Lower extremity flexibility was assessed using the sit-and-reach test. This test was administered using a sit-and-reach box that was 60-cm long, 30-cm high and 30-cm wide. During the measurement, the athletes placed the bottom of their bare feet against the box, leaned forward without bending their knees and held for one to two seconds and then scores were recorded. Measurements were done three times, and the mean score was recorded in cm.

The athletes were tested for static and dynamic balance. Static balance was measured using the Flamingo test. This test was conducted using a balance beam that was 50-cm long, 5-cm high and 3-cm wide. Subjects got on the beam, without shoes and were instructed to stand on it like a flamingo by raising one leg, with their hands on the pelvis. They were asked to keep this position for one minute, and error scores were recorded. Tests were preceded by trial measurements (Jakobsen *et al.*, 2011). Dynamic balance, on the other hand, was measured using the Y balance test. The test consists of three directions: anterior, posteromedial and posterolateral. Reaching distances were measured, and the scores from three successful trials were averaged.

Participants' reaction time was measured using the Nelson hand reaction test. Athletes were seated on a chair, with 90° elbow flexion and the thumb and index finger parallel. A ruler was held vertically in the air between the athlete's thumb and index finger and then released. The point where the athlete caught the ruler was recorded in centimetres. The test was repeated 20 times, and the results of the five fastest and five slowest trials were discarded, and the remaining ones were averaged.

The athletes were assessed for hand-grip strength using a KYTO hand dynamometer. Three measurements were performed with the subject in a seated position, elbow at 90° flexion. Subjects were allowed rest time between measurements. The average of the measurements was recorded in kg. Study data were analyzed using SPPS 25 statistical software suite (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). Categorical and continuous variables were presented in descriptive statistics (mean, standard deviation, median value, first quartile and third quartile). Homogeneity of variance, one of the prerequisites for parametric tests, was checked using Levene's test. Data were tested for normality of distribution using the Shapiro-Wilk test. Differences between two dependent measurements were evaluated using dependent samples t-test when the parametric test prerequisites were met and using the Wilcoxon test when the prerequisites were not met. Statistical significance was set at $p < 0.05$.

## 3. Results and Discussion

The demographic data of the participants is presented in Table 1.

**Table 1:** Demographic Characteristics (n=37)

| **Features** | **Categories** | (*n* (%)) |
|---|---|---|
| Gender | Male | 25 (68%) |
| | Woman | 12 (32%) |
| Generation (WTF) | Green | 3 (8%) |
| | Blue | 6 (16%) |
| | Blue-Red | 2 (5%) |
| | Red | 3 (8%) |
| | Red Black | 1 (3%) |
| | Black Dan1 | 11 (30%) |
| | Black Dan2 | 9 (24%) |
| | Black Dan3 | 2 (5%) |
| Age (Year) | | 22.68±6.708 |
| Height (cm) | | 173.54±7.633 |
| Weight (kg) | | 68.51±15.103 |
| BMI (kg/m$^2$) | | 22.57±3.602 |
| Duration (Month) | | 68.16±64.262 |

SD: Standard Deviation; n: Number; [1]: Dependent Sample t test (t) [2]: Willcoxon test (T)

The taekwondo athletes underwent a number of tests, with and without custom-made mouth guards. Table 2 shows whether the results of these tests differ depending on the use or non-use of a mouth guard. The results show no statistically significant difference

in scores for the T-test, sit-and-reach test, Flamingo balance test, reaction time and hand grip strength between trials with and without a mouth guard (p> 0.05). Table 3 shows that using or not using a mouth guard had no statistically significant effect on all aspects of the Y-Balance test (p > 0.05).

When previous studies were examined, it was found that the mouthguard had a positive or negative effect on some performance parameters. The results of this study showed that the use of custom-made mouth guards did not negatively affect exercise performance in the athletes. While wearing a custom-made mouthguard had no positive effect on performance, it had no negative effect either.

In conclusion, wearing a mouth guard is advisable and should be promoted as it reduces the severity of trauma to the orofacial region. This result supports increasing the use of mouth protection, thereby minimizing the trauma to the oral region.

**Table 2:** Tests with and without Mouthguard Evaluation by Measurements

| | **Without Mouth Guard** | **Mouth Guard** | **Critical Value** | **P** |
|---|---|---|---|---|
| T Test | 10.54±0.79<br>11 (10;11) | 10.40±1.22<br>10 (10;11) | -0.120 | 0.904[2] |
| Sit and Reach Test | 31.66±4.04<br>32 (29;35) | 31.85±3.67<br>32 (30;35) | -0.395 | 0.693[2] |
| Flamingo Balance Movement | 5.51±1.90<br>6 (4;8) | 5.24±1.72<br>6 (4;6) | -1,091 | 0.275[2] |
| Nelson Hand Reaction | 10.70±2.42<br>11 (9;12 | 10.85±2.52<br>11 (9;13) | -0.625 | 0.536[1] |
| Hand Grip | 34.66±8.36<br>36 (29;42) | 34.60±8.44<br>36 (28;43) | -0.485 | 0.628[2] |

*p<0.05; **p<0.01; Mean: Mean; SD: Standard Deviation; M: MedianQ 1 :1. Quarterly; Q3 3. Quarter [1]: Dependent Sample t test (t) [2]: Willcoxon test (T)

**Table 3:** Y Balance Test without Mouth Guard and Mouth Guard Evaluation by Measurements

| | | **Without Mouth Guard** | **Mouth Guard** | **Critical Value** | **P** |
|---|---|---|---|---|---|
| Anterior | Right | 76.30±8.41<br>76 (72;81) | 76.72±7.68<br>78 (71;82) | -0.627 | 0.534[1] |
| | Left | 77.30±8.36<br>78 (72;83) | 77.88±7.99<br>80 (72;84) | -0.983 | 0.332[1] |
| Posterolateral | Right | 93.14±12.66<br>91 (83;101) | 93.44±12.41<br>93 (83;103) | -0.580 | 0.566[1] |
| | Left | 92.84±13.29<br>94 (83;103) | 93.32±11.78<br>92 (82;102) | -0.491 | 0.624[2] |
| Posteromedial | Right | 93.26±10.21<br>91 (85;100) | 94.36±10.81<br>92 (86;102) | -1,883 | 0.068[1] |
| | Left | 93.90±9.43<br>92 (87;102) | 94.16±10.39<br>93 (85;103) | -0.443 | 0.660[1] |

*p<0.05; **p<0.01; *Mean:* Mean*; SD:* Standard Deviation; M: MedianQ 1 :1. Quarterly; Q3 : 3. quarter

There are given as mean ± standard deviation or median (first quartile; third quartile) according to the normality of the data.

This study was designed to investigate the effect of using a custom-made mouth guard on agility, flexibility, balance, reaction time and grip strength parameters in taekwondo athletes. The results showed that using a mouth guard did not affect these exercise parameters, which confirm the H0 hypothesis "Use of a mouth guard by taekwondo athletes does not affect exercise performance parameters."

Initially, sport-specific mouth guards were designed to minimize the incidence of orofacial injury through shock absorption during head and mouth trauma. Besides this preventive function, mouth guards have also been investigated for metabolic, (Garner &McDivitt, 2009; Dudgeon *et al.*, 2017), ventilatory (Amis *et al.*, 2000; Collares *et al.*, 2014) and functional (Nam *et al.*, 2020) effects on neuromuscular performance parameters. Potential neuromuscular effects can be attributed to postural repositioning of the temporomandibular structure and muscle rebalancing. Nakajima *et al.* (2006) performed EMG measurements with boil-and-bite type mouth guards, custom-made mouth guards and without mouth guards.

The results showed that mouth guards reduced the biting reaction time, and this contributed to agility. Busca *et al.* (2018) conducted a study on basketball players who underwent T-tests with and without a mouth guard, and reported that although the difference was not statistically significant, it was close to statistically significant levels. Queiróz *et al.* (2013) examined the effect of three different mouth guards on agility parameters in female soccer players and found that players wearing custom-made mouth guards performed better in the shuttle run test. Moreover, they found no difference between conditions with a custom-made mouth guard (type 3) and without a mouth guard. Also, one study conducted by Golem and Arent (2015) on male college athletes found no significant difference in the results of the hexagonal agility test between those with and without a mouth guard. A study conducted by Cetin *et al.* (2009) on taekwondo athletes found no significant difference in the 10 m and 20 m sprint tests, while Martins *et al.* (2020) reported a significant decrease in the 40 m sprint test time, but no significant difference in the 20 m sprint test. Dunn-Lewis *et al.* (2012) found no significant difference between using a mouth guard and not using a mouth guard in the 10 m sprint test. This result is also supported by Bailey *et al.* (2015) who conducted a study in which recreationally trained male athletes performed L-drill and shuttle run tests with and without a mouth guard. They reported that although the athletes avoided using a mouth guard, there was no difference between the two conditions. The results of the present study show that wearing a custom-made mouth guard did not affect agility performance among athletes. This can be attributed to the adaptation of athletes to wearing a mouth guard as a result of regular use during training and competitions or to the complexity of neuromuscular processes and demand for coordination during agility tests.

Golem and Arent (2015) conducted a study in which male athletes underwent sit-and-reach tests and were assessed for ROM of the shoulder, hip and lumbar region under four different conditions: using a boil-and-bite mouth guard, placebo mouth guard,

custom-made mouth guard and without mouth guard. They found a significant difference in shoulder extension and hip flexion ROM results between measurements with a mouth guard and without a mouth guard. Haughey and Fine (2020) on the other hand, conducted a study on elite athletes and investigated jaw position with and without a mouth guard, and reported that changes in the jaw position when wearing a mouth guard led to a positive effect on athletic performance and a significant improvement in hamstring flexibility in sit-and-reach test results. Dunn-Lewis *et al.* (2012) investigated male and female athletes who underwent the sit-and-reach test with a mouth guard (boil-and-bite and custom-made) and without. They found no significant difference between measurements with a mouth guard and no mouth guard. Drum *et al.* (2016) examined soccer players who undertook the sit-and-reach test while wearing a custom-made mouth guard, boil-and-bite mouth guard and no mouth guard. They found no significant difference among the three conditions. The present study found no difference between measurements of flexibility with and without a mouth guard. Taekwondo techniques require flexibility, and athletes train regularly to develop this skill. That might be the reason why athletes' flexibility performance was not affected by the use of a mouth guard. Wearing a mouth guard changes TMJ positioning in athletes. According to a review of 17 studies examining static and/or dynamic balance caused by the change in stomatognathic function, 15 studies showed that the changing TMJ position was associated with static balance, dynamic balance and postural control, while two studies found no association (Lloyd *et al.*, 2016). Nam *et al.* (2020) used a 3D Formetric device to measure posture and balance in professional basketball players without a mouth guard, with a custom-made mouth guard and with this mouth guard worn for eight weeks (during training and competition). Their results showed significant improvements in static and dynamic balance with the use of a mouth guard.

Dunn-Lewis *et al.* (2012) investigated medial and lateral oscillations in male and female athletes wearing a boil-and-bite and customized mouth guard and without a mouth guard performing a 20-s balance test on the non-dominant leg while standing on a balance board.

They found no significant difference between measurements with a mouth guard and no mouth guard. Cotter *et al.* (2017) compared Modified Star Test results among combat sports athletes with and without a mouth guard. They found no significant difference between the two conditions.

The present study measured static and dynamic balance and found no significant difference. Some of the previous studies have reported that using a mouth guard had positive effects on balance, while others found no effect in line with our study. This difference in results might be attributed to different methods used to measure balance. Garner and Miskimin (2009) measured visual and vestibular reaction time in soccer players with and without a mouth guard using the BIOPAC system. The results showed a significant improvement in vestibular reaction time but no significant change in visual reaction time. Bourdin *et al.* (2006) assessed simple reaction time in athletes with and without a mouth guard. The athletes were instructed to press the button as soon as a

visual signal was received. The results showed no significant difference between the two conditions. Dunn-Lewis *et al.* (2012) compared QuickBoard Visual Reaction Test results in male and female athletes (basketball, soccer, athletics, volleyball and rugby) with and without a mouth guard (boil-and-bite and custom-made). They found no significant difference in the test results with a mouth guard and with no mouth guard. Drum *et al.* (2016) assessed simple reaction time in soccer players with a custom-made mouth guard, boil-and-bite mouth guard and with no mouth guard. Participants were asked to focus on a specific area and catch a released object. They found no significant difference between results with and without a mouth guard. The present study found no significant difference between measurements of reaction time with a mouth guard and with no mouth guard.

This may be because taekwondo involves mutual attacks and requires athletes to constantly adjust their defense and attack position, which activates the reaction time. Previous studies have found no difference between measurements in elite athletes with and without a mouth guard. This result is supported by our study. Based on these results, the reaction time of athletes does not seem to be affected by the use of a mouth guard.

Measurements of isokinetic power showed that biting had a positive effect on slow to medium speed, but not on high speed (Jung *et al.* 2013). Moreover, teeth clenching was found to be positively correlated with maximum force and explosive force (Churei, 2003). Previous studies have also investigated the effect of using a mouth guard on isometric muscle strength. Busca *et al.* (2018) conducted a study with basketball players, and Battaglia *et al.* (2018) with combat sports athletes (taekwondo, karate, jiu-jitsu). They showed that the use of a mouth guard had a positive effect on the dominant hand in the handgrip test. In addition, Cetin *et al.* (2009) evaluated back and leg muscle strength and hand-grip strength in taekwondo athletes with and without a mouth guard using an isometric Takei dynamometer. Their results found no significant difference between the two conditions. Previous studies have investigated the effects of different mouth guards on muscle strength by measuring isometric and isokinetic strengths in certain muscles. Taken together, previous studies suggest that a mouth guard may improve upper extremity isometric muscle strength in physically active individuals and recreational athletes, but does not lead to a significant difference in experienced elite athletes. The taekwondo athletes who participated in this study may have adapted to wearing a mouth guard as they have been practicing this sport for about five years and using a fully-fitted custom-made mouth guard.

## 5. Recommendations

Previous studies have presented conflicting findings regarding the impact of mouthguard use on athletic performance.

While some researchers suggest that customized mouthguards may enhance performance by improving neuromuscular alignment and reducing physiological stress (Garner *et al.*, 2011; Drum *et al.*, 2016), others have reported no significant differences in

agility, strength, or endurance (Cetin *et al.*, 2009; Kececi *et al.*, 2005). The findings of this study align with the latter, indicating that taekwondo athletes do not experience a decline in performance when wearing mouthguards. This suggests that athletes can effectively adapt to their use over time. Given their proven role in preventing orofacial injuries, integrating mouthguards into regular training routines may help normalize their use without compromising performance.

## 6. Limitations of This Study

25 male and 12 female athletes participated in the study. The gender distribution is unequal. Equal gender distribution could have been achieved by including more female athletes. Individuals between the ages of 18 and 40 were included in our study. The wide age range may affect the results. In addition, most of the athletes have a black belt or higher level in taekwondo. If the taekwondo levels of the athletes participating in the study are equal, the results may be affected.

## 7. Conclusion

The present study investigated the effect of custom-made mouth guards on exercise performance parameters in taekwondo athletes and reached the following conclusions;

There was no significant difference in agility, reaction time and flexibility parameters between measurements performed with and without a mouth guard.

There was no significant difference between measurements of static balance in athletes with and without a mouth guard. Mouth guard use did not lead to a significant difference in dynamic balance performance but had a positive effect on the right lower extremity performance in the posteromedial direction, but the difference was not statistically significant.

There was no significant difference in grip strength between measurements with and without a mouth guard.

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**Data Availability Statement**
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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**Conflict of Interest Statement**

The authors declare no conflict of interest.

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