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Relationship Between Mandibular Position, Activation of the Masticatory Musculature and Free-Throw Accuracy in Female Basketball Players

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ABSTRACT

Background: Current research relates jaw clenching to athletic performance, in terms of force and agility. However, the impact of jaw clenching on sports accuracy is unclear.

Objectives: To analyse the impact of jaw position and chewing type on free-throw accuracy and electromyographic (EMG) activity of masticatory muscles during free-throws.

Methods: Cross-sectional study with 25 female basketball players aged 18–44. Each participant executed 18 free-throws under three different jaw conditions: mandibular rest, maximum intercuspation, and with interdental cotton rolls, in randomised order.

Results: Chewing type and jaw position were not associated with shooting accuracy ($p=0.106$; $p=0.778$). There was a positive correlation between EMG activity of the right masseter and free-throw accuracy at maximum intercuspation ($r_s=0.402$; $p=0.046$). In contrast, negative correlations were found with other muscles when the occlusal vertical dimension was altered ($r_s=-0.619$, $p=0.001$; $r_s=-0.490$; $p=0.013$; $r_s=-0.534$; $p=0.006$). The chewing type affected the EMG of the left masseter in the altered occlusal vertical dimension ($H=6.969$; $p=0.031$). Significant differences in EMG recordings were observed across different mandibular positions during free-throws ($p<0.001$).

Conclusions: While jaw positioning and chewing type do not impact free-throw accuracy in amateur female basketball players, the EMG activity of masticatory muscles is linked to shooting performance. This highlights the need for further research on motor behaviour of masticatory muscles in precision sports, especially for athletes using intraoral devices.

1 | Introduction

Numerous studies have shown the possible effects of jaw clenching on athletic performance [1, 2]. Certain authors point out that increased activation of the masseter muscles may increase the force in other muscles [3], thus improving the biomechanics and efficiency of the sporting gesture through the resulting neuromuscular responses [1, 3]. This is known as the concurrent activation potentiation phenomenon (CAP) [4, 5], which is thought to promote greater cortical activation, increased efficiency in motor neuron activity and enhanced reflex responses [4, 6].

Several theories advocate the possible neuromuscular benefits associated with jaw clenching [4]. The first focuses on the integrative function of the motor cortex and the connections between different motor areas of the brain. When one part of the motor cortex is activated by jaw clenching, neural centres in other brain areas co-activate, sending impulses to other motor centres to precisely coordinate the initiation of specific actions. The second theory suggests that the contraction of the masticatory muscles produces increased excitability in alpha motor neurons, gamma loops and neuromuscular spindles, along with decreased cortical and afferent stimulus inputs.

Jaw clenching has been linked to greater facilitation of the H-reflex in certain muscle groups [7]. This facilitation comes from the descending influence in the cerebral cortex and the afferent inputs in the orofacial region. Research using both surface and deep electromyography has demonstrated the activation of cervical muscles and shoulder girdle during different voluntary dental clenching tasks [8–11], and decreased EMG activity of the trapezius and sternocleidomastoid (SCM) muscles in the mandibular resting position [12, 13]. Previous studies have also demonstrated anatomical coupling between the trigeminal and cervical systems, including reciprocal inhibition and muscle coactivations of the jaw, neck and upper limb during the performance of certain tasks [14, 15]. While all these anatomical-functional connections seem to influence masticatory behaviours, they may also be relevant to the performance of other activities of varying complexity, including sports.

Shooting accuracy is essential in basketball where game rules stipulate a fixed shooting distance and no defensive opposition for a free-throw [16]. Basketball coaches emphasise that the movement pattern of free-throws should be sequenced (placing hands on the ball, bringing it to forehead height, bending both the upper and lower limbs before extending them to throw) since it can affect the success of the shot [16–18].

It has been described that the kinematics of the ball, the throwing speed [19] and the angle of release all determine the success of a free-throw [20]. Repeated practice improves control, and we now know that improved postural control impacts on free-throws [21]. Researchers point out that dental occlusion and jaw position may affect postural control depending on certain external interferences especially in conditions of instability, muscle fatigue or both [22, 23]. However, there is still controversy due to the heterogeneity of results [24, 25].

Masticatory muscle contraction may improve the neuromuscular responses of the main muscles involved in a sporting action or gesture due to the CAP phenomenon, which may impact free-throw accuracy. This relationship has not yet been investigated despite the existing evidence on other performance-related parameters for professional basketball players wearing mouthguards [1, 26]. The primary aim of the EMG recordings in this study was to capture the activity of the masticatory muscles (masseter and temporalis) during the execution of free-throws, under varying mandibular positions. The hypothesis driving this methodology is that the neuromuscular engagement of the jaw muscles might influence overall motor coordination and stability during precision tasks such as free-throw shooting based on mechanisms such as the CAP.

The objectives of this study are: (1) to analyse the impact of jaw position and EMG activity of masticatory muscles on free-throw accuracy in amateur female basketball players; (2) to study whether chewing type influences EMG activity of the masticatory muscles in a free-throw; (3) to analyse the effect of different jaw positions on EMG activity in the masticatory muscles.

2 | Methodology

2.1 | Study Design

A cross-sectional observational study was carried out following the STROBE guidelines. Chewing type, EMG activity of the masseter and temporalis muscles, and free-throw accuracy were assessed in three different mandibular positions: the mandibular rest position (RP), maximal intercuspation position (MIP) and increased occlusal vertical dimension position (OVD) (Figure 1). All assessments were made in one single session.

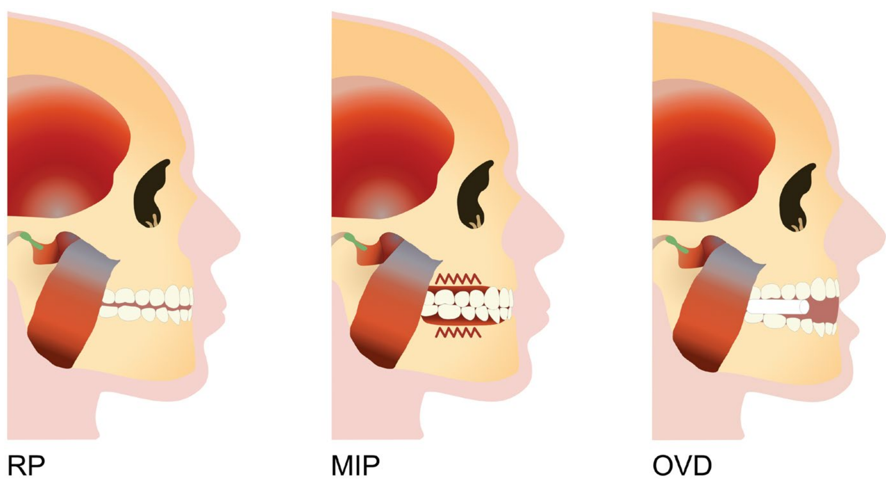

FIGURE 1 | Mandibular positions. RP, rest position; MIP, maximal intercuspation position; OVD, altered occlusal vertical dimension position.

The study was approved by the Institutional Ethics Committee at Camilo José Cela University (code number 09_22_UEMDTT) following the guidelines of the Declaration of Helsinki. All sample subjects read and signed written informed consent before participating in the study.

2.2 | Participants

Twenty-five federated amateur female basketball players from different teams in the Madrid Region, aged between 18 and 44, were recruited to participate in the study. The recruitment and data collection periods took place between February and March 2024.

Participants under 18 years of age, with missing teeth, periodontal disease, temporomandibular disorder, bruxism, or those undergoing orthodontic treatment or wearing occlusal splints were excluded. Participants were also excluded if they had suffered trauma such as mandibular or cranial fractures, postsurgical conditions affecting the craniomandibular region, had undergone previous orthognathic surgery, had received treatment with botulinum toxin in the masticatory muscles in the previous 6 months, had received physiotherapy treatment in the study area in the previous 15 days, or had taken a muscle relaxant in the 48–72 h before the start of data collection [27].

After verifying the inclusion and exclusion criteria, the participants freely and voluntarily signed an information sheet and an informed consent form explaining the study hypothesis and procedure, as well as other issues related to data processing and protection of privacy under current state regulations. We then collected personal, sociodemographic and anthropometric variables using a Google Forms questionnaire.

2.3 | Sample Size Calculation

The minimum sample size of free-throws was calculated for a bilateral repeated-measures test with a 95% confidence level (alpha error = 0.05), a beta error of less than 0.2, a standard deviation of 5, and a minimum detectable difference of 4 units, adjusted for 15% losses. Fifteen shots were required for each round.

2.4 | Assessments and Measuring Instruments

2.4.1 | Assessment of Chewing Type

The unilateral chewing test was used to determine chewing type [28, 29]. Participants were asked to chew a piece of sugar-free chewing gum and open their mouths to show which side of the mouth the gum was on (right or left side). This procedure was repeated 7 times with a time interval of 5 s between each repetition. Participants were classified according to the following criteria: predominant unilateral chewer when they registered 7/7 cycles on the same side, consistent unilateral chewer when they registered 5/7 or 6/7 cycles on the same side, and bilateral chewer (also called alternating unilateral chewer) when they registered same side [29].

2.4.2 | EMG Measurement

Bilateral EMG measurements were taken in one single session, with several measurements of muscle activity in the masseter and the anterior bundle of the temporalis muscles using an mDurance R surface EMG device (mDurance Solutions SL, Granada, Spain) [30]. The system consists of three parts, a portable Shimmer3 EMG unit (Realtime Technologies Ltd. Dublin, Ireland), a mobile application called 'mDurance' (Android), which receives data from the Shimmer3 unit and the mDurance cloud service, where EMG signals are stored, filtered and analysed [30].

EMG sampling cuts were made starting at 0.5 s before the EMG peak coincided with the shot and ending 0.5 s later. This recording method allows us to consider the anticipatory (APAs), secondary to the action (ASAs), and consecutive postural adjustments (CPAs) [31–33]. Raw EMG data were filtered through a fourth-order low-pass Butterworth filter. Raw parameters for mean muscle fibre recruitment (RMS) and maximum voluntary contraction (MVC) data were collected and are expressed as percentages also (%RMS and %MVC).

2.4.3 | Assessment of Free-Throw Accuracy

The accuracy evaluation was conducted on official international basketball courts, where the free-throw is located 4.60 m from the backboard and 5.80 m from the baseline. The basketball hoop is set at a height 3.05 m. We used a regulation-sized ball for women's competitions, with a circumference between 72.4 and 73.7 cm, and a weight between 510 and 567 g (size 6) [34].

All study participants performed the throws with no instruction or imposition on how to execute each personal routine.

Free-throw accuracy was measured in three distinct mandibular positions, performed in a specific order different ordered: RP (closed lips and no dental contact), MIP (closed lips and maximum dental clenching) and OVD (with interposition of cotton rolls 0.8 mm in diameter × 3.8 mm in length between the premolar and molar teeth of both dental arches). Before the throws, all participants were instructed on the randomly assigned order of each mandibular position to be adopted while shooting (Figure 3).

2.5 | Study Protocol

Once the form was completed by each participant, chewing type was evaluated, and results were registered on a recording sheet.

To reduce impedance, each participant's face was cleaned with a 90% alcohol solution. The main investigator placed the electrodes on the masseter muscles and the anterior bundles of the temporalis muscles according to SENIAM protocol [35], using two separate channels for each side, as shown in Figure 2, with the reference electrode placed on the surface of the frontal bone [27]. These electrodes were connected by wires to each of the EMG electrodes.

Maximum voluntary contraction (MVC) of the masseter and temporalis muscles (anterior bundles) was recorded. Participants

FIGURE 2 | Electrode placement according to SENIAM protocol.

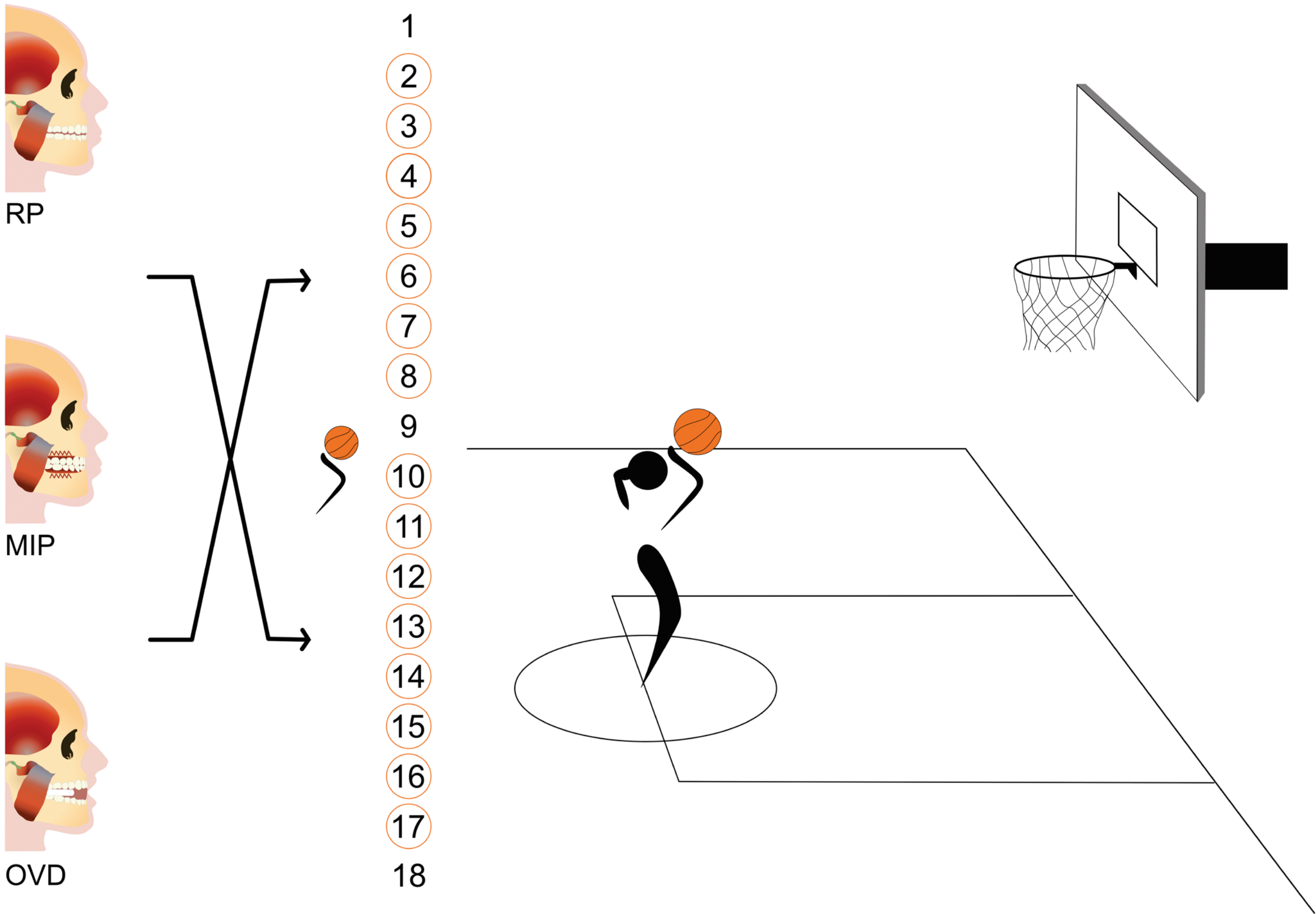

FIGURE 3 | Free-throw in the different randomised mandibular positions. RP, rest position; MIP, maximal intercuspation position; OVD, altered occlusal vertical dimension position.

were asked to perform a maximum dental clench in a maximum intercuspation position for 6 s, followed by a rest time of 2–3 s [27, 36]. The procedure was repeated 6 times. The mean RMS and MVC values obtained were the gold standard for each player's maximal muscle activation. The %RMS and %MVC are expressed as percentages of the values described above. EMG activity of the masticatory muscles was recorded during the free-throws in the different jaw positions.

The players made a total of 54 free-throws, 18 in each randomised jaw position for each participant. Before each set of throws, the players were instructed on the procedure to follow in each jaw position. The instructors only required jaw muscle contraction when performing the shots in the MIP position. One of the evaluators recorded the number of successful shots made in each jaw position on a record sheet, and the total percentage of successful hoops was then calculated. Players rested for one minute between each series of 18 shots. The electromyographic recording of the mandibular muscles was made as specified in Section 2.4.2, except for each first, ninth and eighteenth shots, making a total of 15 study-significant free-throws for each jaw position (Figure 3).

2.6 | Statistical Analysis and Data Processing

The Shapiro–Wilk test was used to test normality of data distribution. When the data were normally distributed, repeated-measures ANOVA parametric tests were used. Nonparametric tests (Spearman's correlation coefficient, Kruskal–Wallis H test and Friedman's test) were used for non-normal distribution data. The chi-square test was used to analyse associations between qualitative variables. The significance level was set at $p \leq 0.05$. All statistical analyses were carried out using the SPSS package (IBM SPSS Statistics for Macintosh, Version 25.0. Armonk, NY, USA: IBM Corp).

3 | Results

3.1 | Descriptive Results and Normality Analysis

Descriptive results (mean ± standard deviation) are shown for age, weight, height, BMI, foot size (European size) and percentage of free-throw accuracy in each jaw position, in normal distribution. Most of the electromyographic data collected were not normally distributed. Both initial MVC and RMS parameters and those derived from the tests in the different jaw positions are not normally distributed (see Tables 1 and 2 for ranges and medians).

3.2 | Inferential Analysis

The repeated-measures ANOVA showed no significant within-subject differences in free-throw accuracy among the different jaw positions analysed ($F_{(2, 48)} = 2.354$; $p = 0.106$). The intrasubject chewing type did not influence accuracy ($F_{(2, 44)} = 2.354$; $p = 0.778$) (Table S1).

For the RMS parameter of electromyographic activity, there was a positive relationship between the maximal intercuspation of the right masseter and the accuracy of the free-throw in this mandibular position ($r_s(23) = 0.402$; $p = 0.046$) and a negative relationship between the right masseter ($r_s(23) = -0.619$; $p = 0.001$), right temporal (r_s $(23) = -0.490$; $p = 0.013$) and left temporal ($r_s(23) = -0.534$; $p = 0.006$) in the OVD position, and percentage of success in that mandibular position. For the MVCs, there was a negative relationship between the activity of the right masseter ($r_s(23) = -0.557$; $p = 0.004$), right temporal ($r_s(23) = -0.451$; $p = 0.024$) and left temporal in OVD ($r_s(23) = -0.436$; $p = 0.029$) in relation to the accuracy of the free-throw in the OVD position (Table 3).

In the percentage of maximum muscle activation, we observed an inverse correlation between the %RMS of the right masseter at rest and the accuracy of the free-throw in resting position ($r_s(23) = -0.431$; $p = 0.031$) and between the accuracy in OVD position and the %RMS of the right masseter ($r_s(23) = -0.558$; $p = 0.004$), right masseter %MVC ($r_s(23) = -0.534$; $p = 0.006$), left masseter %MVC ($r_s(23) = -0.432$; $p = 0.031$), right temporal %RMS ($r_s(23) = -0.458$; $p = 0.021$), left temporal %MVC ($r_s(23) = -0.432$; $p = 0.031$) and right temporal %MVC ($r_s(23) = -0.489$; $p = 0.013$) in OVD (Table 3).

No significant differences were found in the electromyographic activity of the different muscles studied during free-throws regarding chewing type, except for the RMS of the left masseter in OVD position ($H(2) = 6.969$; $p = 0.031$), the %RMS of the left masseter ($H(2) = 7.544$; $p = 0.023$) and the %MVC of the same muscle ($H(2) = 6.410$; $p = 0.041$) (Table S2).

A nonparametric Friedman's test for differences between repeated measures of the RMS, MVC, %RMS and %MVC of the scanned muscles was carried out, yielding a chi-square value of 29.360 ($p < 0.001$) for the right masseter RMS, right temporal RMS ($\chi^2 = 31.760$, $p < 0.001$), left masseter RMS ($\chi^2 = 34.880$, $p < 0.001$) and left temporal RMS ($\chi^2 = 37.520$, $p < 0.001$). The MVCs of the right masseter ($\chi^2 = 15.440$), right temporal ($\chi^2 = 29.354$), left masseter ($\chi^2 = 27.455$) and left temporal ($\chi^2 = 29.360$) muscles were also significantly different ($p < 0.001$). In activation percentages, the χ^2 values were 29.360 for right masseter %RMS ($p < 0.001$), right temporal %RMS ($\chi^2 = 31.760$, $p < 0.001$), left masseter %RMS ($\chi^2 = 34.880$, $p < 0.001$), left temporal %RMS ($\chi^2 = 37.520$, $p < 0.001$), right masseter %MVC ($\chi^2 = 15.440$, $p < 0.001$), right temporal %MVC ($\chi^2 = 29.354$, $p < 0.001$), left masseter %MVC ($\chi^2 = 27.455$, $p < 0.001$) and left temporal %MVC ($\chi^2 = 29.360$, $p < 0.001$).

4 | Discussion

Our results show that neither jaw position nor chewing type affects free-throw accuracy. To the best of our knowledge, there are no data from similar studies on the relationship between free-throw accuracy and different mandibular positions, where vertical dimension of occlusion is altered [37]. In similar studies on putt accuracy in golf, no significant differences have been reported among professional golfers with varying molar contact through mouthguards and stabilisation splints [38]. However, a significant increase in both club head speed and drive distance was observed when these types of devices were worn. Dias et al., analysing the shot accuracy of pistol shooters at 10 m, found no significant differences when comparing occlusal splints versus placebo splints, although a nonsignificant decrease in shot dispersion was found [39]. Schulze and Busse [2] compared the accuracy of passing, defensive reception, and serving in a group of volleyball players with and without dental guards, observing an increase in the EMG activity when intraoral devices were used. Unlike our research, EMG measurements of the masseter, temporalis, 'cervical group' (not specified) and digastric muscles were taken while the players

TABLE 1 | Descriptive statistics data.

Variable	Mean	SD	95% CI
Age	29.28	8.40	25.81–32.75
Weight	62.64	6.58	59.92–65.36
Height	1.72	0.07	1.68–1.74
BMI	21.28	1.99	20.45–22.09
Shoe size	39.64	1.72	38.93–40.34
% Accuracy RP	59.78	21.41	50.94–68.62
% Accuracy MIP	51.56	16.55	44.72–58.39
% Accuracy OVD	58.23	22.69	48.86–67.59

Abbreviations: BMI, body mass index; MIP, maximal intercuspation position; OVD, altered occlusal vertical dimension position; RP, rest position.

TABLE 2 | Descriptive statistics data (non-normal).

Variable	MVC test		FT RP		FT MIP		FT OVD	
	Median	Range	Median	Range	Median	Range	Median	Range
RMS								
Right masseter	177.77	670.26	29.25	128.35	151.33	522.69	33.38	113.04
Right temporal	171.98	593.51	21.35	319.41	136.82	332.07	24.14	57.13
Left masseter	174.48	725.91	23.00	296.63	161.53	926.45	23.89	112.43
Left temporal	167.16	441.69	28.97	112.83	153.93	233.31	33.35	110.11
MVC								
Right masseter	266.43	1196.26	100.21	579.00	259.88	966.83	111.78	517.67
Right temporal	242.43	1008.72	53.12	1298.19	235.76	492.28	69.79	293.42
Left masseter	261.36	1293.51	76.50	1156.10	291.40	4945.52	61.73	474.05
Left temporal	237.96	679.76	112.82	382.76	309.64	424.44	117.94	470.50

Abbreviations: FT, Free-throw; MIP, maximal intercuspation position; MVC, maximum voluntary contraction; OVD, altered occlusal vertical dimension position; RMS, muscle fibre recruitment; RP, rest position.

were seated, assessing RP, MIP and OVD with interdental cotton rolls in place before the sports activity, not during it.

What is generally observed with the use of intraoral devices in sporting activity is an increase in strength in non-masticatory muscles, particularly in jumping, explosive strength, maximum strength and running kinematics [4, 26, 40]. This increase in strength is believed to result from the CAP described by Ebben [4], where an increase in cortical activation produced by the action of the masticatory muscles would lead to activation of other areas of the cortex. Although shooting accuracy is highly dependent on the subject's visuomotor afferents and the reduction or interruption in motor activity [41], other physical factors such as shot preparation, postural control, the distance between the ball and the ground as it leaves the player's hand, the angle of the shot, the frequency of backward ball spin, and the smoothness of the executed movements have been described [16]. These same authors point out that the timing and variability of biceps and triceps brachii muscle activation influence free-throw accuracy, with expert players showing higher scores for both parameters compared to intermediate and novice players. Cabarkapa et al. performed biomechanical analyses of the free-throw accuracy of players of different proficiency levels using a 3D motion capture system, observing significantly lower peak and mean angular velocities at the knee and center of mass in the more proficient free-throw shooters [42]. This highlights the importance of considering individual skill levels and their impact on shooting accuracy. Therefore, factors such as postural control, exerted strength, balance or muscle response to fatigue may be influenced by masticatory muscle activity [22, 23, 43]. The impact of cognitive processes such as motivation, self-controlled practice and attention has also been described in studies of free-throw accuracy. We found that increased electromyographic activity of the muscles explored in the altered OVD position significantly worsened free-throw accuracy. Greater accuracy, however, is observed in the activity of the right masseter in the MIP position. Although this may be associated with the CAP mechanism, the worsening of free-throw accuracy in OVD seems to be associated with muscular hyperactivation, which should not be the case. In our view, OVD is the most concerning position for players regarding MVC, RMS, %MVC and %MVC parameters, especially for temporalis muscle EMG data. As we observed that mandibular position was not related to accuracy, it is suggested that altering the occlusal vertical dimension affects trigeminal system comfort and, consequently, its function, as evidenced by significantly different EMG data. This relationship could be explained by a different neuromuscular response due to the influence on trigeminal proprioception through afferent connections of the cranial nerve V in the CNS. Changes in dynamic and static body balance, posture and muscle tone of the masseters, SCOM and spinal erectors have been observed when dental occlusion is modified [23, 40]. Possible relationships between the viscoelastic properties of certain muscle groups and the dental interposition of cotton rolls have also been described through the temporomandibular system-body fascia interrelation [44, 45]. This relationship has yet to be conclusively proven, and some authors believe that all information passes through and is regulated by the CNS [9]. These possible interactions are becoming more relevant as the use of mouthguards in contact sports to avoid the risk of orofacial injury is common [40, 46, 47]. Depending on the type of mouthguard or splint used, there are variations in the vertical dimension of the athlete's occlusion as well as the force and velocity exerted by different muscle groups [48, 49].

The relationship between trigeminal afferents and the vestibular nuclei has been demonstrated in mammals, observing their role in the stabilisation of gaze and postural control through the integration of this information in the CNS with that from the cervical spine and the proprioception of the oculomotor muscles [50, 51]. Suvinen and Kemppainen [52] argued that EMG activity of the masticatory muscles in healthy subjects does not differ, showing only moderate changes in OVD position. Dysfunctional subjects treated with intraoral devices exhibit reduced activation of masseter and temporalis muscles, being significant for improving performance in power, flexibility, balance, stability and posture. Additionally, it may

TABLE 3 | Spearman's correlations between EMG parameters and accuracy percentage in the different mandibular positions.

	% Accuracy RP	% Accuracy MIP	% Accuracy OVD
Masseters			
RMS			
R	−0.306	**0.402**	**−0.619**
Sig.	0.136	**0.046**	**0.001**
L	−0.113	0.293	−0.304
Sig.	0.591	0.155	0.139
% RMS			
R	**−0.431**	0.101	**−0.558**
Sig.	**0.032**	0.629	**0.004**
L	−0.197	−0.076	−0.334
Sig.	0.345	0.719	0.102
MVC			
R	−0.258	0.296	**−0.557**
Sig.	0.212	0.151	**0.004**
L	−0.043	0.243	−0.232
Sig.	0.839	0.241	0.265
% MVC			
R	−0.364	0.086	**−0.534**
Sig.	0.074	0.683	**0.006**
L	−0.133	0.184	**−0.432**
Sig.	0.525	0.380	**0.031**
Temporalis			
RMS			
R	−0.265	0.233	**−0.490**
Sig.	0.201	0.263	**0.013**
L	−0.356	0.096	**−0.534**
Sig.	0.081	0.649	**0.006**
% RMS			
R	−0.232	0.073	**−0.458**
Sig.	0.265	0.727	**0.021**
L	−0.316	−0.140	**−0.432**
Sig.	0.124	0.505	**0.031**
MVC			
R	−0.279	0.281	**−0.451**
Sig.	0.177	0.173	**0.024**
L	−0.307	0.020	**−0.436**
Sig.	0.135	0.925	**0.029**

(Continues)

TABLE 3 | (Continued)

	% Accuracy RP	% Accuracy MIP	% Accuracy OVD
% MVC			
R	−0.170	0.108	**−0.489**
Sig.	0.416	0.607	**0.013**
L	−0.250	−0.309	−0.359
Sig.	0.228	0.133	0.078

Note: Bold values indicate the correlation index (R), and the statistically significant value (Sig).
Abbreviations: L, left; MIP, maximal intercuspation position; MVC, maximum voluntary contraction; OVD, altered occlusal vertical dimension position; R, right; RMS, muscle fibre recruitment; RP, rest position.

help prevent future injuries, given the correlation between occlusal activity and sport activity, where occlusal parafunctions can occur during certain periods [53]. In any case, the mechanisms by which individuals with TMD can benefit from such devices remain unclear. In our study, we did not use interdental devices other than cotton rolls, but it would be interesting to study EMG activity in players wearing mouthguards or splints during precision activities, monitoring the effect at the time of the sporting act. While these effects might be more challenging to observe directly, the precise measurement of jaw muscle activity provides a window into understanding how even minor neuromuscular adjustments can impact outcomes in sports where accuracy is critical. Finally, the different EMG activities observed in each mandibular position only confirmed that the players understood what was asked of them in each free-throw, since the highest activation peaks and RMS were reflected during MIP compared to the other mandibular positions. Since the highest activation peaks and RMS were reflected during MIP compared to the other mandibular positions.

Further research is needed to explore the relationships between electromyographic activity recorded in the masticatory muscles and free-throw shooting accuracy. In-depth studies should differentiate sample groups by skill level (beginner, intermediate, elite), the presence or absence of temporomandibular disorders, various game or shooting scenarios, or even by analysing other sports where accuracy is a key factor.

4.1 | Limitations

The main limitations of the study derive from the homogenisation of the sample selection, since although the initial questionnaire asked the participants to comment on the presence or absence of pain in the temporomandibular region, this alone does not determine the presence of a disorder. Furthermore, multivariate analysis with larger sample sizes might yield different results. Certain occlusion parameters, such as crossbite, scissor bite, or mediotrusive interference, which could alter the activation patterns of the masticatory muscles, were not considered. Moreover, individual characteristics such as the dominant chewing side or neuromuscular coordination patterns, or asymmetrical muscle function could be potential confounding factors. Another limitation is that the free-throw measurements were not taken in a real competition context but during training sessions. Additionally, the presence of electrodes and wiring necessary for the electromyographic recording may have impacted the throw.

5 | Conclusions

Jaw position is not associated with free-throw accuracy in amateur female basketball players. The chewing type exhibited by each player did not influence free-throw accuracy percentage. Electromyographic activity recorded from the masseter and temporalis muscles is associated with accuracy, showing a positive relationship at MIP and a negative relationship at the OVD position. Further research is needed to explore the impact of masticatory muscle motor behaviour may have on shooting performance in basketball or other precision sports, particularly in individuals who use intraoral devices.

Author Contributions

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Consent

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Raw data will be made available upon request to the corresponding author.

Peer Review

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Supporting Information

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