Universidade Federal de São Carlos
Centro de Ciências Biológicas e Saúde
Departamento de Fisioterapia
Programa de Pós Graduação em Fisioterapia
Laboratório de Cinesiologia Clínica Ocupacional

Bruno Leonardo da Silva Grüninger

COMO OCORREM OS MOVIMENTOS DA MANDÍBULA E DA CABEÇA EM SUJEITOS COM DISFUNÇÃO TEMPOROMANDIBULAR E EM SUJEITOS SAUDÁVEIS?

Orientadora: **Profª Drª Ana Beatriz de Oliveira**

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Dissertação apresentada ao Programa de Pós-graduação em Fisioterapia, do Centro de Ciências Biológicas e da Saúde da Universidade Federal de São Carlos como parte dos requisitos para obtenção do título de Mestre em Fisioterapia. Área de concentração: Processo de Avaliação e Intervenção em Fisioterapia

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UNIVERSIDADE FEDERAL DE SÃO CARLOS

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Aos meus pais, Alex e Ângela (sempre presente)

À minha amada esposa, Marina

À minha família

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É tão bonito quando a gente sente que nunca está sozinho, por mais que pense estar (...)”

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“Algumas pessoas querem que algo aconteça,
outras desejam que aconteça,
outras fazem acontecer”
(Michel Jordan)

RESUMO

Considerando a carência de estudos que avaliam a relação entre articulação temporomandibular e componentes cervicais em atividades dinâmicas, este estudo objetivou investigar a cinemática e o controle motor da cabeça e da mandíbula e avaliar a performance dos músculos cervicais em pacientes com disfunção temporomandibular comparado com sujeitos saudáveis. Foram coletadas cinemática da cabeça e mandíbula em 71 mulheres (Grupo saudável – HG: N=33; Grupo Disfunção temporomandibular – TMDG: N=38) durante movimentos cervicais (flexão – extensão, rotação e inclinação), e durante atividades funcionais (abertura máxima da boca (MMO), fala, mastigação e uso do computador). Frequência mediana foi calculada para as posições da cabeça nas atividades funcionais. Foi analisada a correlação cruzada para séries de tempo da mandíbula e cabeça durante atividades funcionais. O controle motor da cabeça (Senso de posição articular – JPS) e performance dos músculos cervicais (teste de flexão crânio cervical – CCFT) também forem testados. Os grupos foram comparados usando Teste-T para amostras independentes ou seu correspondente não-paramétrico, Mann-Whitney. Não foram encontradas diferenças para o JPS e CCFT, enquanto que a abertura máxima da boca foi maior para o grupo saudável. Frequência mediana foi maior para a posição da cabeça do grupo saudável, no plano sagital durante o uso do computador em comparação com o TMDG. Isso pode indicar uma maior variação e melhor estratégias motoras para o HG. Correlação cruzada mostrou correlação negativa entre cabeça e mandíbula durante a MMO. No entanto, a consistência dessa correlação foi fraca em outras atividades. Parece que quanto maior a exigência biomecânica, mais forte é a correlação. Estudos mais aprofundados devem focar-se em tarefas mais complexas.

Palavras-chaves: Cinemática, Articulação temporomandibular

ABSTRACT

Considering the lack of studies assessing the relationship between temporomandibular joint and neck components in a dynamic approach, this study aimed to investigate kinematics and motor control of the head and jaw in functional and isolated activities, and to evaluate cervical muscle performance and motor control of the head in temporomandibular disorder (TMD) patients compared to healthy subjects. Kinematics of head and jaw were recorded from 71 women (Healthy Group – HG: N= 33; Temporomandibular Disorder Group – TMDG: N=38) during neck movements (flexion-extension, rotation and lateral bending), and functional tasks (maximal mouth opening (MMO), speaking, chewing and computer use). Median frequency was calculated for head positions in functional tasks. Cross-correlation analysis was performed for the time series of jaw and head recorded in functional tasks. Motor control of the head (joint position sense - JPS), and cervical muscle performance (craniocervical flexion test - CCFT) were also tested. TMDG and HG were compared using independent t-test or Mann-Whitney test. No difference was observed in CCFT and JPS, while jaw depression was larger in HG. Median frequency was higher for head position of HG in sagittal plane during computer use in relation to TMDG. It may indicate more variation and better motor strategies in HG. Cross-correlation analysis showed a clear negative correlation between head and jaw in MMO. However, the consistency of this correlation was weak in other tasks. It seems that the higher the biomechanical requirement the stronger the correlation. Further studies should focus on more complex tasks.

Key-words: Kinematics, Temporomandibular joint

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LISTA DE ABREVIATURAS

TMD	*Temporomandibular Disorder* – Disfunção Temporomandibular
TMJ	*Temporomandibular Joint* – Articulação Temporomandibular
BMI	*Body Mass Index* – Índice de Massa Corpórea
HG	*Health group* – Grupo Saudável
TMDG	*Temporomandibular Disorders Group* – Grupo Disfunção Temporomandibular
FAI	*Fonseca Anamnesic Index* ndice Anamnésico de Fonseca
NDI	Neck Disability Index
RDC/TMD	Critérios de Diagnóstico de Pesquisa/ Disfunção Temporomandibular
MMO	*Maximal Mouth opening* – Abertura Máxima da Boca
JPS	*Joint Position Sense* –Senso de posição articular
CCFT	*Crânio cervical flexion test* - Teste de Flexão Crânio-Cervical
CE-R	*Constant Error – Right* -Erro Constante Direita
CE-L	*Constant Error – Left* - Erro Constante Esquerda
AE-R	*Absolut Error – Right* - Erro Absoluto Direita
AE-L	*Absolut Error – Left* - Erro Absoluto Esquerda
VE-R	*Variable Error – Right* - Erro Variável Direita
VE-L	*Variable Error – Left* - Erro Variável Esquerda
RMSE - R	*Root Mean Square Error – Right* Erro Quadrático Médio Direita
RMSE - L	*Root Mean Square Error – Left* - Erro Quadrático Médio Esquerda
ROM	*Range of motion* – Amplitude de Movimento
SD	Desvio padrão
MF	Frequência mediana
Hz	Hertz

Sumário

CONTEXTUALIZAÇÃO

A articulação temporomandibular (ATM) é importante em diversas atividades essenciais do ser humano, como alimentação, comunicação e expressão facial (Calixtre et al, 2014). Portanto, trata-se de uma das articulações do corpo humano que mais se movimenta. Em situações normais, os côndilos direito e esquerdo se movimentam em conjunto a fim de executar depressão, elevação, lateralização e protrusão da mandíbula – movimentos fundamentais para realização das atividades funcionais (Armijo-Olivo 2012). A abertura da boca ou depressão da mandíbula depende do rolamento posterior de ambos os côndilos mandibulares sob os discos articulares e translação anterior do complexo côndilo-disco na fossa mandibular do osso temporal. Esses movimentos são controlados pelos músculos mastigatórios e qualquer alteração nessas estruturas pode causar discinesia uni ou bilateral e disfunção do sistema mastigatório (Neumann et al, 2006). A disfunção temporomandibular (DTM) é definida como um grupo de alterações do sistema estomatognático, como dos músculos mastigatórios, articulação temporomandibular (ATM) e estruturas associadas, as quais podem estar relacionadas com dores de cabeça, pescoço, ombro e coluna cervical (Bender, 2014).

Pacientes com DTM frequentemente apresentam alterações na coluna cervical, assim, essa relação tem sido investigada. Estudos mostraram movimentos coordenados entre mandíbula, cabeça e pescoço para realizar atividades de abertura e fechamento da boca, conhecido como "integração funcional": durante o movimento de abertura máxima da boca, há a necessidade de uma extensão da coluna cervical alta. (Eriksson et al., 2000, Zafar et al., 2000).

Existem três diferentes teorias que tentam elucidar essa relação funcional: a neuroanatômica, a biomecânica e a muscular.

A relação neuroanatômica é explicada através de convergências de neurônios nociceptivos que recebem inputs sensoriais trigeminais e cervicais, visto que o arranjo topográfico do núcleo caudal trigeminal permite troca de informação nociceptiva entre os nervos espinhais e o trigêmeo. Desta forma, o estímulo de estruturas inervadas pelo nervo trigêmeo causa sensação dolorosa na região cervical e no pescoço (Leandri et al., 2001). Ainda, estudos experimentais em animais revelaram considerável convergência de fibras aferentes craniofaciais e cervicais no tronco cerebral trigeminal (Leandri et al., 2001). Devido a essa convergência, dor na região cervical pode ser percebida nas estruturas orofaciais e o oposto também pode ocorrer.

A relação biomecânica apresenta sua explicação baseada na movimentação do crânio, mandíbula e coluna cervical. No inicio do movimento de abertura da boca, o crânio precisa deslizar anteriormente, assim ocorre o movimento de extensão na articulação atlânto-occpital, e ao mesmo tempo, os dentes superiores devem deslizar para a frente, uma vez que estão ligados ao crânio e, consequentemente, a posição dos dentes de contato desloca-se posteriormente até a posição de intercuspidação. Quando o crânio desliza para trás, ocorre a situação inversa. Portanto, os movimentos craniocervicais causam movimentos adaptativos na mandíbula e em estruturas associadas (Armijo-Olivo et al., 2006). Uma vez que esses movimentos adaptativos estejam restritos, tanto a mandíbula quanto estruturas associadas podem estar alteradas (Armijo-Olivo et al., 2006). Previamente, já foi descrito na literatura que o controle integrado entre a cabeça e a mandíbula pode ser afetado através de restrição mecânica da cabeça (Häggman-Henrikson et al., 2006).

Do ponto de vista apenas muscular, estudos que induziram dor no masseter demonstraram aumento da contribuição de estruturas cervicais durante movimentos de abertura-fechamento da boca. (Wiesinger et al., 2013) observaram que, mesmo que a amplitude de abertura tenha permanecido semelhante pré e pós injeção de solução salina, a estratégia do controle do posicionamento da cabeça e da mandíbula foi altera da após a estimualção nocioceptiva na região trigeminal. Essa estratégia de controle motor diz respeito às informações sensoriais enviadas pelos neurônios aferentes para as estruturas responsáveis pela execução do movimento da cabeça, no caso.

Como a coluna cervical é em grande parte dependente do apoio dos músculos cervicais, eles acabam sendo altamente propensos a fadiga, o que reduz o seu desempenho e, consequentemente, o equilíbrio entre músculos flexores e músculos extensores do pescoço se apresenta comprometido.

Armijo-Olivo et al. (2010) também identificaram um aumento na atividade eletromiográfica dos músculos flexores cervicais superficiais em indivíduos com DTM, observado através do teste de flexão crânio cervical, indicando que essa hiperativação pode representar uma diminuição da atividade dos músculos cervicais profundos.

Além disso, as aferências proprioceptivas do pescoço têm uma importante contribuição para o posicionamento da cabeça e sua orientação espacial (Pinsault et al, 2010). Esse posicionamento da cabeça, mandíbula e sua orientação podem ser percebidas através do sistema de controle neural da cabeça e pescoço, que depende da convergência de sinais proprioceptivos, vestibulares e visuais (Lakie e Loram, 2006) e que, já foi apresentado que patologias cervicais não específicas alteram o controle motor cervical (Revel et ai. 1991). A influência aferente dos músculos cervicais é conhecida como tendo o papel principal do controle da postura da cabeça (Pinsault et al., 2008). Desta forma, o mau funcionamento destes músculos provoca um alinhamento inadequado das estruturas e, portanto, disfunção cervical.

Para esse componente de controle motor, Revel e colaboradores (1991) desenvolveram um teste clínico de fácil aplicação para verificar a sensação de posicionamento da cabeça durante a sua rotação. Acredita-se que se a musculatura cervical está sofrendo de algum fator inerente (isto é, sentido alterado da posição), todo o complexo funcional (cabeça-mandíbula) poderia ser alterado. Isto acontece porque a cabeça teria uma má orientação espacial ou porque mudanças na força muscular, resistência ou qualidade da ativação muscular aumentaria a irritação dos tecidos sensíveis do pescoço, causando dor e consequentemente perpetuando dor nas regiões cervical e orofacial (Armijo-Olivo e Magee, 2012).

Armijo-Olivo et al. (2011a) identificaram diversos estudos que tentaram demonstrar alguma relação entre o movimento da cabeça, coluna cervical e o sistema estomatognático. No entanto, as informações fornecidas pelos estudos incluídos são baseadas em dados descritivos e apresentam baixa qualidade metodológica (Chaves et al., (2014). Além disso, poucos estudos fornecem informações relevantes sobre movimentos funcionais e mais complexos. A maioria dos estudos está focada na avaliação da abertura e fechamento da boca, protrusão e lateralização da mandíbula. Visscher et al (1991), por exemplo avaliou a abertura da boca a partir de uma posição pré-estabelecida fixa da cabeça. Estudos que e exploram e comparam o comportamento da cabeça e mandíbula entre indivíduos saudáveis e com DTM são ainda mais raros.

Embora haja estudos que analisam e confirmam essa integração funcional (Häggman-Henrikson et al, 2002; Eriksson, et al., 2004) ainda há necessidade de se correlacione mecanismos integrativos durante atividades dinâmicas e funcionais.

Assim, o objetivo dessa dissertação foi investigar a cinemática e o controle motor da cabeça e mandíbula em atividades funcionais e isoladas de ambos os segmentos, bem como avaliar o desempenho muscular cervical e o controle motor cervical em indivíduos com DTM quando comparados a indivíduos saudáveis. A hipótese principal é de que os sujeitos com DTM apresentarão diminuição do controle motor dos movimentos da cabeça e redução da função da musculatura cervical. Além disso, esperamos que a "integração funcional" seja alterada em indivíduos com DTM em comparação com indivíduos saudáveis. O estudo que atendeu o desenvolvimento desse objetivo é apresentado a seguir.

ESTUDO

How do jaw and head movements occur in TMD patients and healthy subjects?

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Introduction

Temporomandibular disorder (TMD) has been related to dysfunction and pain of the masticatory muscles (Ferreira et al., 2014), and represents approximately 40% of all chronic pain problems (Mongini et al., 2007). TMD is also associated with symptoms affecting head and neck such as headache, neck dysfunction and altered posture (Silveira et al., 2014). Literature supports the interdependence between temporomandibular joint (TMJ) and neck structures, since the disease or injury in one area may induce pain and/or dysfunction in other area (La Touche et al., 2015).

The combination of jaw and head movements has been addressed as functional *integration* (Nordh, 1998), and it seems to be task-dependent (Eriksson et al., 2000). Functional integration depends on the coordination of jaw and neck muscles, providing simultaneous movements of TMJ, atlanto-occipital joint and cervical spine (Zafar et al., 2000). For example, chewing is associated to an extension of the upper cervical, identified from the movement of the head. Moreover, during elevation of the jaw, head returns to its initial position or does a small flexion. Thus, considering this relationship between neck and TMJ regions, an alteration in one of the regions can possibly influence the other, and vice versa (Visscher et al., 2000b; Eriksson et al., 2007; La Touche et al., 2015).

Three theories are described to elucidate this relationship. The neuroanatomic theory is supported by the convergence of nociceptive neurons receiving trigeminal and cervical sensory inputs due to the topographical arrangement. Thus, the stimulation of structures innervated by the trigeminal nerve may causes a painful sensation in the cervical region and in the neck (Leandri et al., 2001).

Another theory addresses biomechanics to explain that when the head slides anteriorly on the atlas, there is extension in the atlanto-occipital joint; at the same time, the upper teeth must slide forward since they are connected to the skull, and, consequently, the position of the contact teeth moves posteriorly to intercuspidal position. When skull slides backwards, opposite situation occurs. Therefore, craniocervical movements cause adaptive changes in the jaw and associated structures. However, the ranges for such adaptive movements are diminished. Thus, any decrease in jaw and associated structures may lead to dysfunction (Armijo Olivo et al., 2006).

Finally, the third theory involves motor control. Studies inducing pain in masseter muscle demonstrated an increase in the contribution of the cervical component during mouth opening-closing movements (La Touche et al., 2015). The injection of saline solution in the masseter region produced a painful stimulus, but the opening width of the mouth remained similar before and after injection (Wiesinger et al., 2013). The motor control strategy between the jaw and the head was altered after stimulation of the trigeminal region.

It has been previously described that the integrated control between head and jaw can be affected by mechanical restriction of the head (Häggman-Henrikson et al., 2006). Cervical spine is highly dependent on the support of the neck muscles, exposing them to fatigue, and, consequently, to altered performance (Armijo-Olivo et al., 2010). Armijo-Olivo et al. (2010) have also identified an increase in electromyographic activity of the superficial cervical flexor muscles in subjects with TMD, while there was a decrease in strength and resistance of deep cervical flexor and extensor muscles. Furthermore, subjects with neck disability were induced to pain in the masticatory system, and showed an increase in fatigue and pain in the region of the cervical musculature (La Touche et al., 2015).

Proprioceptive inputs of neck region have an important contribution to the positioning of the head and its spatial orientation (Pinsault et al., 2008). Neural control system of the head and neck depends on the convergence of proprioceptive and visual signals (Lakie and Loram, 2006). Thus, Revel et al. (1991) considered that non-specific cervical pathologies alter cervical motor control and afferent input from the cervical muscles (Pinsault et al., 2008). Therefore, malfunctioning of these muscles causes an inappropriate alignment of the structures and neck disability. Thus, if cervical musculature is suffering from some inherent factor (i.e, altered sense of position), the entire functional complex (head-jaw) could be altered.

Despite evidence for an association between the neck and TMJ structures, this relationship has been investigated using static measures (Chaves at al., 2014). A systematic review, aiming to evaluate studies correlating postural changes with TMD (Armijo-Olivo, 2012), found only three studies with moderate or strong methodological quality, accomplishing that studies with greater scientific rigor need to be performed to strength the evidence of this relationship. Moreover, there is a lack of information about functional and more complex movements. In general, studies are focused on the evaluation of mouth opening and closing, protrusion and lateralization of the jaw, always starting from a fixed pre-established position of the head (Visscher et al., 2000a).

Therefore, the objective of the this study was to investigate kinematics and motor control of the head and jaw in functional and isolated activities of both segments, as well as to evaluate cervical muscle performance and motor control of the head in individuals with TMD when compared to healthy subjects. We hypothesized that TMD patients will present decreased motor control of the head, and reduced cervical musculature function. Moreover, we expect *functional integration* of jaw and head to be impaired in individuals with TMD compared to healthy subjects.

Methods

Participants

Seventy-one women with mean age of 26.86 (±7.76) years, and body mass index (BMI) of 22.26 (±2.86) kg participated in the study. According to inclusion and exclusion criteria (see below), subjects were divided into two groups: HG (Healthy Group; N= 33 subjects; mean age of 28.2 ±10.15 years, BMI of 22.08±2.77 kg/m²) and TMDG (Temporomandibular Disorder Group; N=38 subjects; mean age of 25.63±4.41 years; BMI of 22.42±2.96 kg/m²). All subjects signed an informed consent form approved by the local ethics committee (Process #1.790.335/2016).

To be included in the HG, subjects had to present less than 3 points according to the Numerical Pain Rating Scale (NPRS) applied for both neck and TMJ regions; less than 20 points to Fonseca Anamnestic Index (FAI); less than 4 points in the Neck Disability Index (NDI). In order to be included in the TMDG, subjects had to be diagnosed with myogenic or mixed TMD, according to Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD) (Dworking, 1992).

Subjects were excluded if present history of jaw fracture, TMJ luxation, systemic ligament laxity, pregnancy, rheumatic or neurologic system diseases, orthodontics or physical therapy treatment in the last six months, and previous cervical or oral surgery.

TMD subjects, according to RDC/TMD, presented the following diagnoses:

- 10 subjects – Ia (Myofascial pain without limited mouth opening);
- 28 subjects – Ib (Myofascial pain with limited mouth opening);
- 24 subjects – IIa (disc displacement with reduction);
- 1 subject IIb (disc displacement without reduction with limited mouth opening);
- 1 subject IIc (disc displacement without reduction without limited mouth opening);

- 11 subjects IIIa (Arthalgia);
- 1 subject IIIc (Osteoarthrosis with joint pain).

Considering a statistical power of 80%, and alpha level of 0.5, the estimated sample size was 16 participants in each group (G*Power, version 3.0.10). Maximum mouth opening (MMO) was considered as the main outcome. Data for TMD subjects were estimated from literature (Felicio et al., 2013) as 22.86±4.2 mm. We considered healthy subjects with MMO of 27.9±4.2 mm, according to data from a pilot study. Minimal clinically important difference was set at 9 mm (Kropmans, 2000). Once this study is part of larger research, we decided to include more subjects in the sample since data were available.

Assessment protocol

Special tests and kinematic evaluation were performed by a blind rater, in pre-set order.

Special tests

Joint Position Sense test – JPS: Applied to evaluate head motor control from the ability to reposition the head to reach a target (Johnston et al., 2008; Jull et al., 2008). The subject was seated in front of a target (90 cm away), with a laser pointer fixed on the top of the head, and pointing to the center of the target (Figure 1A). She was instructed to perform 10 movements of maximal rotation of the head to each side (Figure 1B). The order of movements (to the right or left) was random. When she positioned her head back to the supposed initial position, a mark was made on the target where the laser was pointing. At the end, a picture of the target was recorded, from a distance of 2 m, to be later analyzed (CorelDraw X5). We calculated, for both right and left directions:

- CE (constant error): mean of the raw error over the ten trials to each side incorporating the positive and negative values in each trial, i.e. $\frac{\sum_{n=1}^{10} raw\ error\ n}{10}$ (Lee et al., 2006; Hill et al., 2009);

- AE (absolute error): the mean of the total deviation from the starting point over the ten trials to each side, ignoring positive (overshoot) and negative (undershoot) values – absolute raw error, i.e. $\frac{\sum_{n=1}^{10} absolute\ raw\ error\ n}{10}$;

- VE (variable error): root mean square of the difference between the raw error and the calculated CE, i.e. $\frac{\sqrt{\sum_{n=1}^{10}(raw\ error\ n - CE\ n)^2}}{10}$;

- RMSE (root mean square error): square root of the sum of the CE squared and the VE squared, i.e. $\sqrt{CE^2 + VE^2}$.

Craniocervical Flexion Test - CCFT: Applied to evaluate the performance of deep cervical flexor stabilizing muscles in the cervical spine (Chiu, 2005; Jull et al., 2008). CCFT is an indirect assessment of activation (observed as activation scores - AS), and resistance (observed as cumulative performance indexes - CPI) of deep cervical flexors, as proposed by Jull et al., (2008). Test is performed using a pressure biofeedback device located in the neck region (Stabilizer, Chattanooga Group Inc.), and a visual aid positioned in front of the subject, with the subject lying supine, keeping the legs flexed (Figure 1C). Each participant attempted to reach 5 different levels. The device has a graduation with marks corresponding to increments of 2mmHg, ranging from 20mmHg to 30mmHg. The level of effort required in the test is progressive, and observed according to what the subject can perform. In order to move to the next level, the subject must be able to complete ten 10-second repetitions on each possible level.

The use of superficial musculature or the presence of some compensation on the movement is expected when subject is unable to continue. CPI was calculated as: AS * repetitions + the sum of maximum scores obtained at the previous levels. For example, if a subject was able to move successfully through 2 levels of contraction, and was able to complete 6 repetitions before presenting compensations, her CPI was calculated as follows: 4 * 6 + 20 = 44. A perfect CPI of 300 is obtained if the participant can progress through all levels without showing signs of compensations and/or fatigue.

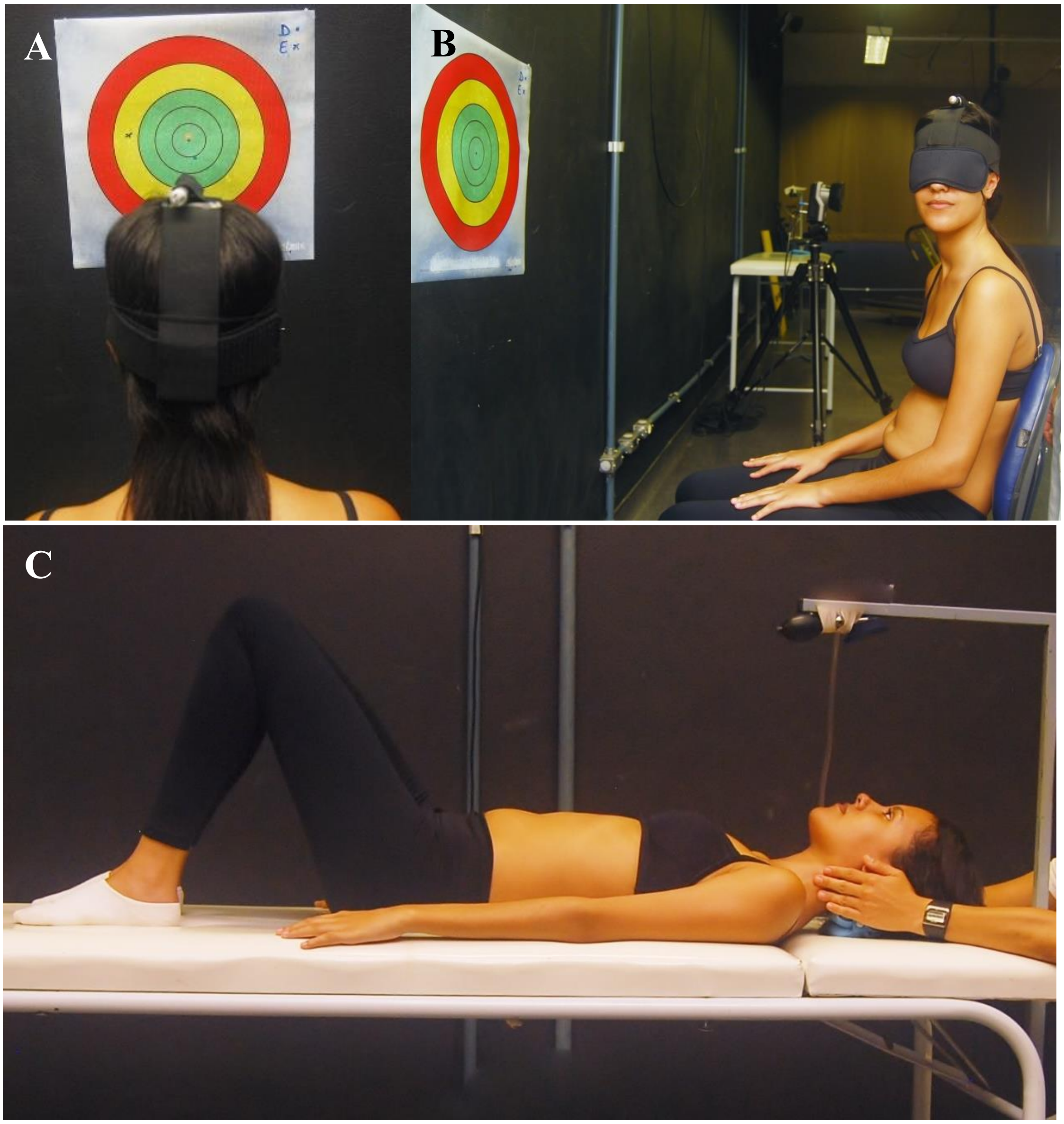

Figure 1. (A) Starting position in JPS test, with laser pointer on the top of the head pointing to the center of the target; (B) Subject performing left head rotation during JPS test; (C) Positioning of subject and evaluator during CCFT.

Kinematics

A six-camera Qualisys motion capture system (Qualisys, Inc., Gothenburg, Sweden) was used to perform kinematic analysis of head and jaw movements. Data was recorded at 120 Hz. Fifteen markers and one cluster device were used (Figure 2). Trunk movements were reconstructed from six (20 mm) markers positioned on the spinous processes of C7 and T10, right and left acromion, sternal notch and xiphoid process. The head plan was formed by a marker on the glabella (12 mm), and three markers (15mm) fixed on a plastic tiara: two were placed one centimeter above each ear (temporal region) and the third at the midpoint of these points, at the top of the head

(Figures 2A and 2B). Three markers (12 mm) were positioned at the corners of an equilateral triangular stainless steel extraoral cluster (size 40 mm; weight 2 g). The cluster was fixed on the mandibular anterior gingiva using a surgical adhesive to provide a mandibular reference system, together with markers (12 mm) on the TMJs and mandibular angles (Mapelli et al., 2009; Sforza et al., 2008). In the static trial, an additional marker was located on the midline incisal edge to identify a virtual dental landmark relative to the cluster. The 3D-reconstruction of the jaw was then obtained.

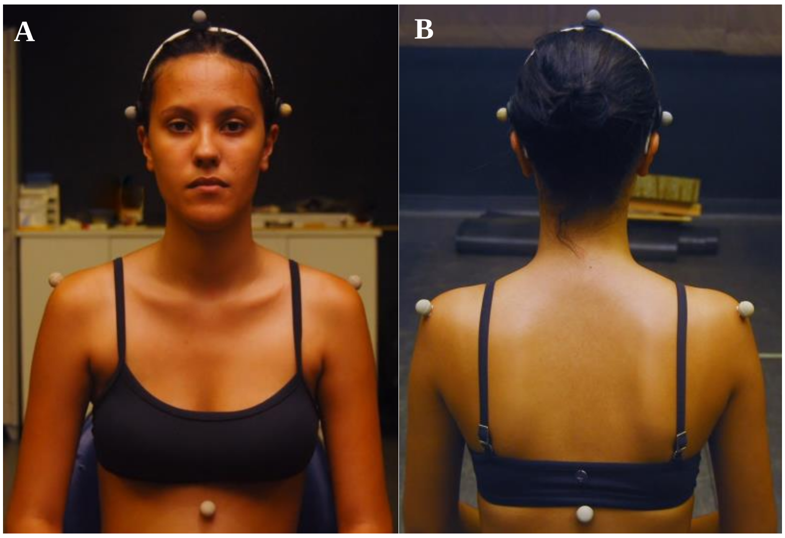

Figure 2. (A and B) Position of the markers on head, trunk and jaw.

For organizational reasons and better presentation of the results, we divided the kinematics into two phases: isolated and functional movements.

Isolated head movements: In order to record head position in neck movements, subject was instructed to perform a series of 3 movements: maximal neck flexion-extension, right and left rotation, right and left lateral neck bending. All movements were performed three times for each side. The movements were always initiated from the neutral position of the neck, and performed at free speed.

Functional movements: head and jaw movements were recorded with the subject seated on a regular non-adjustable chair. She was asked to perform:

1) Maximal mouth opening (MMO) at free velocity, starting from the mandibular intercuspidal position;

2) Reading out loud a sequence of 11 predetermined words, chosen for presenting several phonemes of the Brazilian Portuguese language, in her habitual speed and tone of voice. This task was labeled as speaking;

3) Chewing for 20 seconds on the side of her preference. A standardized piece of flexible, odorless, colorless film was used (Biasoto-González, 2010), and the chewing was performed at free speed.

4) A laptop computer was positioned on a regular office table, and each subject selected a text of preference to read. The recording was performed during 600 seconds, and the volunteer was instructed to sit on a regular non-adjustable chair to perform computer use (Figure 3A e 3B).

During the recording of all functional movements, some markers were lost. Therefore, we proceed with a careful data control quality, and exclusion of subjects for specific recordings. Therefore, the number of subjects in each analysis is presented with the results.

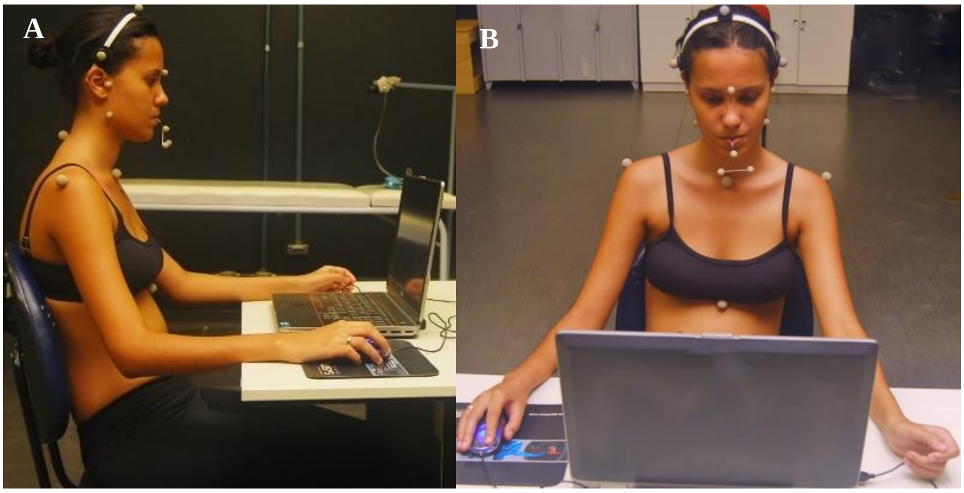

Figure 3. (A and B) Markers and data collection during computer use.

Data processing: Qualisys Track Manager (Qualisys AB Packhusgatan, Gothenburg, Sweden), and Visual 3D (C-Motion, Inc., Germantown, MD, USA) software were used to track the position of the markers and to reconstruct 3-D movements of each segment, respectively. Rotational movements were identified and Cardan Angles θx, θy e θz were obtained (Mapelli et al., 2009).

Tridimensional displacement of the head in relation to the trunk was subtracted from movements of the jaw in order to isolate any movement of the head occurred during functional and isolated tasks (Mapelli et al., 2009).

The 3D angular displacement of the jaw and head was processed using MatLab (v7.0.1, MathWorks Inc., Natick, MD, USA).

For the isolated movements, we extracted the maximal position of jaw depression, head flexion, extension, bending and rotation. Head position during maximal jaw depression was also obtained. During functional tasks, jaw and head position in frontal, sagittal and transverse planes were analyzed. Positive and negative values refer to the movement direction in each plane - sagittal (+: jaw elevation and head extension), frontal (+: jaw lateral deviation right and right head bending), and transversal (+: jaw protrusion and left head rotation). In order to extract information about motor control of the head, median frequency of 3-D head position was calculated in MMO, speaking, chewing and computer use through the Fast Fourier Transformer (FFT).

A cross-correlation analysis was performed between the time series of head and jaw angular positions in the sagittal plane recorded during MMO, speaking, chewing and computer use. Cross-correlation coefficients (r^2) were calculated for zero-lag (CC zero-lag) between time series. Maximal absolute cross-correlation coefficients (CC max), for all possible time lags, were also calculated. Was considered negative and positive values of CC max separately, in order to verify any specific behavior in HG and TMDG. Considering that craniocervical movements cause adaptive changes in the jaw and associated structures (Armijo Olivo et al., 2006), we expected to find negative correlation coefficients, showing that head extension was combined to jaw depression during functional tasks. Coefficients between 0 and 0.19 were considered as "little if any correlation"; from 0.20 to 0.39 as weak correlation; between 0.40 and 0.69 as moderate correlation; from 0.70 and 0.89 as strong correlation; values higher than 0.9 as very high correlation (Munro, 2005).

Statistical Analysis

All data were descriptively presented as mean and standard deviation values. Normality and homoscedasticity were investigated through Shapiro-Wilk and Levene’s tests, respectively. The comparisons between HG and TMDG were performed using t-test for independent samples or Mann-Whitney test, according to the assumptions. Statistical analysis was performed using SPSS v.23 and alpha level was set at 0.05.

Results

Results of special tests, CCFT and JPS, are shown in Table 1. No significant difference was observed. However, mean value of CCFT was higher for HG compared to TMDG. HG also had higher variability in this test compared to TMDG.

Table 1: Mean and standard deviation (SD) values of results of special tests. Statistical results (*P*-value) for the comparison between TMD and Healthy subjects are also presented.

	TMD Group mean (SD)	**Healthy Group mean (SD)**	***P*-value**
CCFT	49.47 (34.00)	68.24 (62.40)	0.268
JPS			
CE-R	4.91 (1.82)	4.86 (2.09)	0.927
CE-L	4.93 (2.26)	4.57 (2.37)	0.593
AE-R	4.91 (1.82)	4.86 (2.09)	0.927
AE-L	4.93 (2.26)	4.57 (2.37)	0.377
VE-R	22.76 (11.51)	22.57 (9.14)	0.840
VE-L	23.67 (15.16)	26.29 (12.05)	0.377
RMSE-R	655.52 (650.58)	612.87 (537.18)	0.849
RMSE-L	795.20 (1022.70)	864.13 (765.81)	0.177

TMD: temporomandibular disorder; CCFT: craniocervical flexion test; JPS: joint position sense; CE-R: constant error right; CE-L: constant error left; AE-R: absolut error right; AE-L: absolut error left; VE-R: variable error right; VE-L: variable error left; RMSE: root mean square error; -R: right side; -L: left side.

Isolated movements were performed in similar and maximal amplitude by subjects from both groups (Table 2). Therefore, jaw depression was larger in healthy subjects ($P<0.05$). Head extension was also larger in HG, but no significant difference was identified.

Table 2: Mean and standard deviation (SD) of maximal range (in degrees) recorded during isolated movements, and head position during maximal jaw depression (in degrees). Statistical results for the comparison between temporomandibular disorders (TMD) and Healthy groups are also presented. Positive or negative values are associated to the direction of movement - head extension, right bending, and left rotation have positive values, while jaw depression, head flexion, left bending and right rotation have negative ones.

	TMD Group mean (SD)	**Healthy Group mean (SD)**	***P*-value**
Jaw depression	-20.85 (6.87)	-26.91 (4.17)	0.000*
Head position at jaw depression	4.23 (3.46)	4.95 (2.59)	0.306
Head flexion	-66.20 (10.12)	-65.32 (11.17)	0.876
Head extension	56.37 (11.59)	62.21 (15.18)	0.053
Head bending - R	39.05 (6.36)	38.43 (7.55)	0.648
Head bending - L	-39.99 (6.27)	-39.11 (7.40)	0.377
Head rotation - R	44.74 (6.76)	68.64 (9.97)	0.473
Head rotation - L	-66.31 (9.18)	-70.14 (10.42)	0.117

* $P<0.05$, t-test for independent samples. TMD: temporomandibular disorder; -R: right side; -L: left side.

Table 3 shows mean and standard deviation of 3D movements recorded during speaking, chewing and computer use. Once again, movements were similar between TMDG and HG, except for the head position on transversal plane during computer use – subjects from TMDG have presented a more pronounced head rotation to the left than HG (*P*<0.05).

Table 3: Mean and standard deviation values (in degrees) of tridimensional movements recorded for jaw and head during speaking, chewing and computer use. Data are reported as mean and standard deviation (SD). Statistical results (*P*-value) for the comparison between TMDG and HG are also presented. Number of subjects included in each group is presented (N). Positive or negative values are associated to the direction of movement – jaw elevation, head extension, right bending, and left rotation have positive values, while jaw depression, head flexion, left bending and right rotation have negative ones.

	Speaking			**Chewing**			**Computer Use**		
	TMDG (N=36) mean (SD)	**HG (N=33) mean (SD)**	***P*-value**	**TMDG (N=37) mean (SD)**	**HG (N=33) mean (SD)**	***P*-value**	**TMDG (N=29) mean (SD)**	**HG (N=33) mean (SD)**	***P*-value**
Jaw - sagittal plane									
Mean	-0.90 (1.24)	-0.65 (1.32)	0.414	-0.31 (1.25)	-0.37 (1.72)	0.915	7.16 (8.51)	5.75 (6.15)	0.456
Standard Deviation	1.80 (0.36)	1.72 (0.44)	0.402	2.13 (0.86)	1.95 (0.92)	0.346	2.22 (0.96)	2.58 (2.83)	0.516
Jaw - frontal plane									
Mean	-0.07 (0.34)	-0.07 (0.50)	0.838	-0.04 (0.34)	-0.06 (0.45)	0.636	1.10 (2.26)	-9.22 (59.92)	0.313
Standard Deviation	0.22 (0.10)	0.26 (0.14)	0.285	0.41 (0.18)	0.42 (0.28)	0.686	1.17 (0.79)	1.77 (4.15)	0.877
Jaw - transversal plane									
Mean	-0.01 (0.46)	0.01 (0.35)	0.973	0.02 (0.37)	0.06 (0.43)	0.717	-0.17 (6.88)	1.24 (3.76)	0.358
Standard Deviation	0.23 (0.10)	0.20 (0.07)	0.180	0.42 (0.18)	0.47 (0.66)	0.954	1.09 (0.79)	1.06 (1.02)	0.448
Head - sagittal plane									
Mean	1.60 (1.78)	1.82 (1.49)	0.577	0.43 (1.05)	0.53 (1.09)	0.583	-3.65 (6.55)	-3.73 (5.01)	0.960
Standard Deviation	1.02 (0.50)	0.97 (0.46)	0.686	0.57 (0.24)	0.68 (0.39)	0.175	2.42 (1.18)	2.48 (1.27)	0.852
Head - frontal plane									
Mean	0.06 (1.06)	0.17 (0.98)	0.532	-0.29 (0.76)	-0.01 (0.63)	0.264	-1.22 (4.94)	1.12 (3.76)	0.375
Standard Deviation	0.53 (0.30)	0.58 (0.38)	0.087	0.37 (0.26)	0.34 (0.38)	0.359	2.61 (1.62)	2.50 (1.54)	0.725
Head - transversal plane									
Mean	-0.23 (0.73)	-0.37 (1.10)	0.661	0.08 (0.79)	-0.15 (0.67)	0.114	2.71 (3.38)	2.03 (2.63)	0.039*
Standard Deviation	0.64 (0.37)	0.85 (0.60)	0.520	0.43 (0.34)	0.35 (0.37)	0.653	1.74 (0.85)	1.66 (0.93)	0.789

* P<0.05, t-test for independent samples; TMDG: temporomandibular disorder group; HG: healthy group.

Table 4 shows data of median frequency (MF) of head movements during functional tasks and MMO. Significant differences were observed in frontal and transversal planes for MMO and in sagittal plane for computer use. In all situations healthy subjects had higher median frequency than TMD patients. Variability across subjects was quite similar in both groups.

Table 4: Mean and standard deviation (SD) values of median frequency (Hz) of the head during MMO, speaking, chewing and computer use. Number of subjects (N) in each condition and group, and statistical results for the comparison between TMD and Healthy subjects are also presented.

	TMDG		**HG**		***P*-value**
	N	**mean (SD)**	**N**	**mean (SD)**	
Sagital plane					
Jaw depressionMMO	38	0.29 (0.07)	33	0.34 (0.11)	0.097
Speaking	36	0.26 (0.13)	33	25.73 (0.17)	0.449
Chewing	37	0.31 (0.13)	33	34.09 (0.11)	0.482
Computer use	29	0.07 (0.14)	33	4.30 (0.10)	0.025†
Frontal plane					
MMO	38	0.26 (0.13)	33	0.35 (0.14)	0.010*
Speaking	36	0.17 (0.09)	33	0.17 (0.10)	0.933
Chewing	37	0.22 (0.09)	33	0.24 (0.11)	0.773
Computer use	29	0.04 (0.01)	33	0.02 (0.04)	0.466
Transversal plane					
MMO	38	0.23 (0.10)	33	0.32 (0.13)	0.004*
Speaking	36	0.17 (0.09)	33	0.16 (0.08)	0.923
Chewing	37	0.21 (0.08)	33	0.26 (0.17)	0.218
Computer use	29	0.05 (0.07)	33	0.04 (0.87)	0.078

* P<0.05, t-test for independent samples; † P<0.05, Mann-Whitney test. TMD: Temporomandibular disorders; MMO: maximal mouth opening.

Results of cross-correlation analysis are presented in Table 5. In general, the correlation between head and jaw movements on the sagittal plane was mostly negative. It means that jaw depression was combined with head extension. A significant difference happened for zero-lag cross-correlation in the chewing time series. High or very high correlation was observed during MMO. However, no consistent difference was observed between groups. Therefore, variability across subjects was higher among TMD patients than among healthy subjects.

Little if any correlation was found in speaking, chewing and computer use when looking at CC zero-lag and CC max. Therefore, analyzing negative and positive values separately, moderate to strong correlation was observed for both groups, and moderate correlation during speaking in healthy subjects. The only statistical significant difference between TMDG and HG was found for CC zero-lag in chewing.

Table 5: Results of the cross-correlation (CC) analysis (r^2) performed between jaw and head movements in the sagittal plane during MMO, speaking, chewing and computer use. The analysis was performed for zero-lag between the time series (CC zero-lag). Maximal cross correlation (CC max) was also calculated, for all lag combinations. Positive and negative CC max results are shown separately. Data are reported as mean and standard deviation (SD). Statistical results for the comparison between TMD and Healthy subjects are also presented.

	TMD Group		**Healthy Group**		***P*-value**
	N	**mean (SD)**	**N**	**mean (SD)**	
MMO					
CC zero-lag	38	-0.75 (0.36)	33	-0.80 (0.16)	1.000
CC max	38	-0.76 (0.37)	33	-0.83 (0.14)	1.000
CC max negative	36	-0.85 (0.08)	33	-0.84 (0.10)	0.713
CC max positive	2	0.74 (0.04)	0	-	-
Speaking					
CC zero-lag	38	-0.18 (0.51)	33	-0.09 (0.50)	1.000
CC max	38	-0.24 (0.57)	33	-0.15 (0.56)	1.000
CC max negative	24	-0.57 (0.17)	22	-0.61 (0.15)	0.374
CC max positive	14	0.55 (0.17)	11	0.59 (0.23)	0.647
Chewing					
CC zero-lag	37	-0.14 (0.36)	33	0.09 (0.51)	0.034*
CC max	37	-0.12 (0.46)	33	0.10 (0.58)	0.116
CC max negative	25	-0.38 (0.29)	15	-0.49 (0.17)	0.249
CC max positive	13	0.46 (0.19)	18	0.49 (0.37)	0.069
Computer use					
CC zero-lag	29	-0.38 (0.64)	33	-0.45 (0.68)	0.327
CC max	29	-0.40 (0.67)	33	-0.50 (0.70)	0.401
CC max negative	21	-0.79 (0.20)	22	-0.62 (0.47)	0.512
CC max positive	8	0.61 (0.26)	11	0.65 (0.20)	0.816

* $P<0.05$, t-test for independent samples; MMO: maximal mouth opening.

In order to illustrate the correlation between head and jaw movements, graphs in Figure 4 show the time series of such movements, in sagittal plane, for one representative subject from each group. Data of MMO, speaking, chewing and computer use are presented. X-axis was standardized to improve visualization.

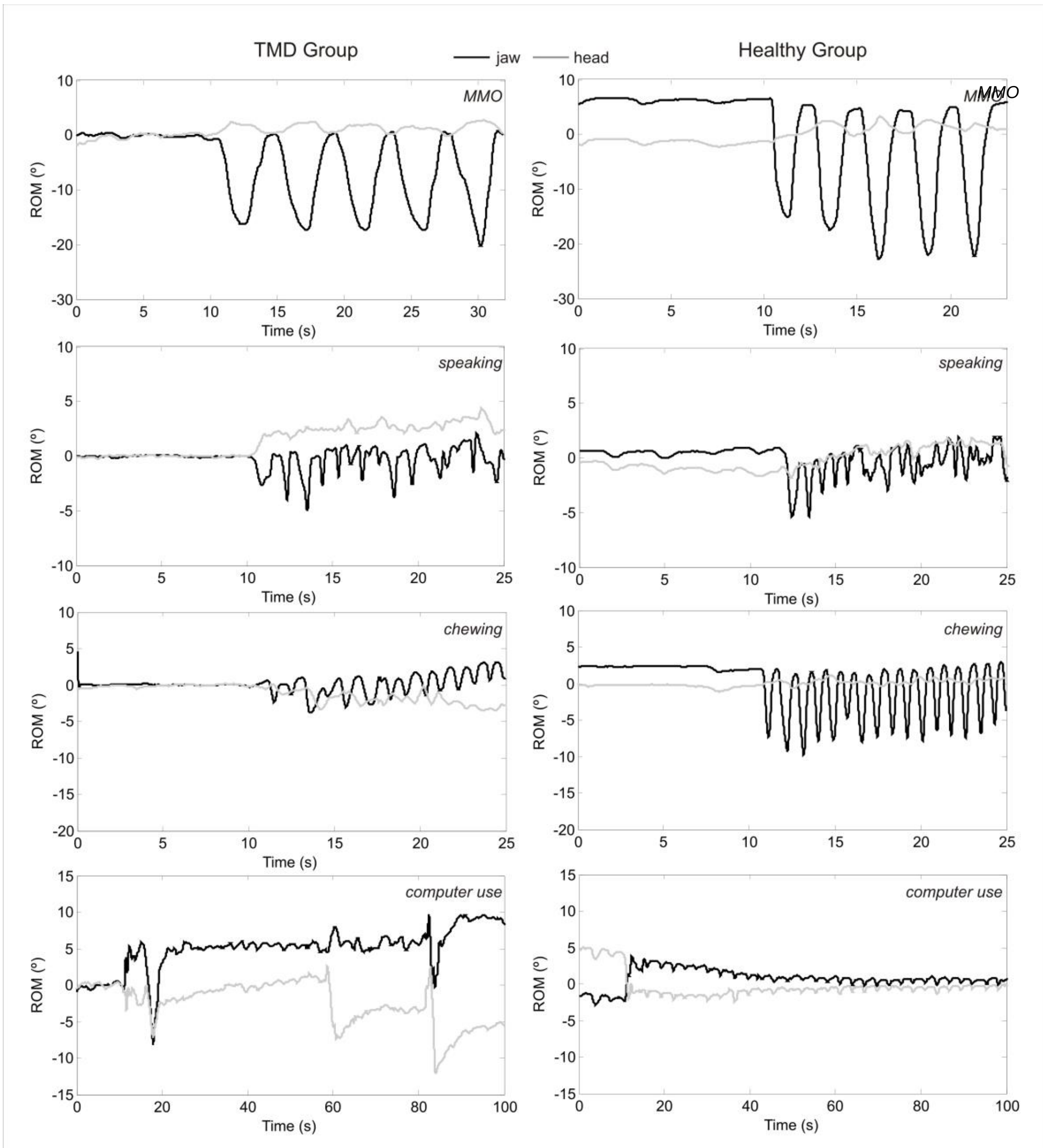

Figure 4. Time series of the jaw (gray line) and head (black line) movements in sagittal plane for one representative. Maximal mouth opening (MMO), speaking, chewing and computer use data are presented. Axes X representing time (s) and Y representing Range of Motion (ROM), in degrees.

Discussion

According to our findings, jaw and head movements occur in a similar way in TMD patients and healthy subjects. However, TMD patients have limited MMO. We could show the combination of head and jaw movements, called functional integration, happens in a very clear way during MMO. On the other hand, this combination was not consistent across subjects during speaking, chewing and computer use. No differences in the performance of JPS and CCFT were observed between groups.

Observing the maximal range recorded during isolated movements, only the MMO had significant difference between groups. Mapelli et al (2016) found a decrease in MMO in individuals with chronic TMD, however, with no statistical difference. TMDG may present a protection mechanism to avoid pain and, therefore, reduction in MMO. Considering that maximal ROM can be achieved in simple and involuntary activities, such defense may play an important role in protecting TMJ.

We have not found any difference on JPS among healthy and TMD subjects. However, studies using similar methodology in subjects with craniocervical dysfunction (DCC) found significant differences compared to healthy subjects (Pinsault et al., 2010; Sarig et al., 2014). Considering the muscular relationship between craniocervical and TMD dysfunctions (Armijo-Olivo et al., 2015), we hypothesized that subjects with TMD would present alteration in motor control of the head, what has not happened. We believe that difference on methodology can explain these findings. JPS test has been performed using sophisticated computer-based software (de Vries et al., 2015), but we decided to perform a clinically feasible test, as proposed by Roren et al (2009).

CCFT has not shown difference between groups. According to the literature, reduced cervical flexor endurance was expected in TMD subjects (Armijo-Olivo and Magee, 2012; Jull and Falla, 2016). However, these studies usually evaluate the electromyography activity of the superficial flexors during CCFT and hardly take into account the number of repetitions and the load made on the test.

Heterogeneity of TMD diagnosis can explain the lack of difference when comparing TMD patients to healthy subjects. The inclusion of subjects with mixed TMD brings components that influence both the articular discs and TMJ articular surface. Only 10 subjects had only myofascial components, where relations based on changes in muscular system could, maybe, be better observed. In addition, our sample may not have several mandibular functional impairment.

Besides looking at regular kinematics data, such as mean and peak movements, two different approaches were used – median frequency (MF), in frequency domain; cross-correlation analysis, in time domain. MF indicates the frequency of oscillation of the time series and, consequently, of the movement. The larger the MF, the greater the oscillation during the task. We intended using the MF as an indicator of motor control of the head. Thus, we expected greater MF values for the TMDG compared to HG.

However, we found higher MF for HG, particularly for head position in sagittal plane during computer use. It may indicate a better use of motor strategies resulting in greater motor variability when compared to TMDG (Srinivasan, 2015).

Currently, motor variability has been reported in studies as a positive factor (Chau et al., 2005). Such variability may indeed have an important functional role in skill acquisition and prevention of overuse injuries (Srinivasan and Mathiassen, 2012). Motor variability refers to the intrinsic variability naturally present in the motor control system. It occurs even in the simplest movements, and is usually manifested as a difference in joint movements, joint coordination and/or muscle activities between successive repeats of a task (Srinivasan, 2012). Therefore, we have to assume that MF was the only metrics used, and that we are speculating that it may say something about motor variability. The fact that the main difference has appeared in sagittal plane during computer use reinforces this idea since it was recorded in a long period of time if compared to other tasks. Further studies may consider the use of other metrics. Another important aspect is that few information about physiologically or clinically interesting effect sizes in motor variability is available making it difficult to compare data (Côté et al., 2005).

Still addressing motor variability, it is important to consider that extrinsic factors such as pace, accuracy demands and workstation configuration are expected to affect motor variability (Srinivasan et al., 2015). In our study, subjects performed all tasks in a free pace. It might be that the control of some parameters would result in different behavior of each group, not only in computer use, but also in MMO, speaking and chewing tasks. Moreover, the extent of variability in a single movement component (the head, in our case) from one body segment may not be sufficient to evaluate the entire information present in motor variability. Functional movements like chewing or speaking require coordination of multiple muscles, joints and body parts, such as jaw movement, masseter muscle activation, and also head stabilization through the coordinated action of neck muscles. We have shown a small piece of information, and this component of motor variability should be deeply investigated in further studies, including other functional activities relevant to TMD patients.

The cross-correlation analysis, also applied as a different approach to kinematics data, confirmed the functional integration between head and jaw in the sagittal plane during dynamic recordings of different tasks corroborating with Häggman-Henrikson et al., (2006). This result was very consistent for maximal mouth opening, where all subjects (expect two of TMDG) presented high or very high negative correlation between head and jaw. For those subjects, head extension was strongly combined to jaw depression, as described in the literature (Häggman-Henrikson et al., 2006; Eriksson et al., 2007). During the other tasks, we also observed correlation between jaw depression and head extension, but the behavior was very variable across subjects. However, most of the subjects always presented negative correlation between head and jaw movements, varying from strong and moderate correlation. We believe that the consistence observed in MMO is related to the larger range of motion performed in this task, that require the subject to perform maximal jaw depression. Other studies have already reported that the type of food used to evaluate chewing may influence the behavior of the masticatory system (Eriksson et al., 2007). Therefore, we do believe that other tasks involving more biomechanical demand, such as biting an apple or chewing resistant food, could rise up interesting information. The challenge on doing that is the use of precise kinematics recording since it always requires intraoral apparatus or markers.

This study has some limitations. The subjects of this study present heterogeneity of TMD classification. Moreover, our patients did not really present severe dysfunction and it’s demonstrated by the low functional impairment and the lack of difference between TMDG and HG in CCFT and JPS. Possibly, the assessment of patients with more severe symptoms would present different results. Therefore, our results are valid to an important part of the TMD patient population, comprising people that show limitations in jaw depression and pain. On the other hand, to our knowledge, this is the first study investigating dynamic patterns of head and jaw movements and its combination in subjects with TMD.

Conclusion

The results of this study show similar behavior in head and jaw movements performed by TMD patients and healthy subjects. They also support the correlation between head extension and jaw depression in both healthy and TMD subjects. However, motor variability seems to be greater in healthy subjects if compared to TMD patients, particularly during computer use.

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CONSIDERAÇÕES FINAIS E DESDOBRAMENTOS FUTUROS

A realização do presente estudo possibilitou verificar o comportamento similar que ocorreu para as variáveis cinemática, independente da condição clínica do indivíduo em relação à disfunção temporomandibular. A verificação de como ocorre o mecanismo de integração funcional entre cabeça e mandíbula também foi importante.

Embora não tenha havido, como esperado, diferença entre os grupos para as variáveis estudadas, foi possível aplicar, de forma inédita na literatura, outros tipos de análises em condições funcionais diversas. Essa metodologia pode auxiliar na compreensão do tema em futuros estudos. A correlação entre a cabeça e mandíbula em movimentos funcionais pode ser verificada e, embora não tenha sido identificada diferença estatística entre os grupos, compreende um tema para novas investigações.

Futuramente é importante pensar em avaliar atividades biomecanicamente mais desafiadoras, como mastigar alimentos mais resistentes e maiores. Também é importante entender o mecanismo antecipatório que o individuo realiza logo no começo de todas as atividades, onde parece haver uma grande oscilação da coordenação dos movimentos da cabeça. Análises que envolvam medidas clinicamente reprodutíveis também são importantes de serem consideradas.

Esses aspectos são importantes para o entendimento global e amplo do paciente com DTM, visando melhorar abordagens e tratamentos conservadores, ampliando o olhar para outros segmentos além da articulação temporomandibular.

Apêndice I

Parecer do Comitê de Ética em Pesquisa em Seres Humanos

UFSCAR - UNIVERSIDADE FEDERAL DE SÃO CARLOS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Cinemática e controle motor da cabeça e mandíbula de indivíduos com e sem disfunção temporomandibular em atividades funcionais

Pesquisador: Bruno Leonardo da Silva Grüninger

Área Temática:

Versão: 2

CAAE: 53904816.4.0000.5504

Instituição Proponente: Departamento de Fisioterapia

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.790.335

Apresentação do Projeto:

Trata-se de um estudo transversal que será constituído de uma avaliação de dois grupos, sendo o Grupo controle composto por indivíduos saudáveis e o Grupo Disfunção Temporo Mandibular "DTM" composto por indivíduos que apresentem DTM miogênica ou mista.O estudo será realizado no Laboratório de Cinesiologia Clinica e Ocupacional e serão incluídas mulheres, com idade entre 18 e 40 anos, saudáveis ou com sintomas de DTM, que serão recrutadas a partir de ampla divulgação, convidando-as para participar do estudo.Tem como hipótese que o comportamento das variáveis seja diferente entre os grupos, com pobre coordenação dos movimentos da mandíbula em relação à cabeça, redução da função muscular e orientação espacial deficitária nos indivíduos com DTM.

Objetivo da Pesquisa:

O pesquisador responsável descreve como objetivo primário "investigar o comportamento integrado da cabeça e da mandíbula em atividades funcionais e isoladas da mandíbul" e como objetivo secundário "avaliar o comprometimento da função muscular e da propriocepção cervical em indivíduos com e sem DTM"

Avaliação dos Riscos e Benefícios:

O pesquisador descreve como riscos que "Durante a avaliação física você poderá sentir algum desconforto visto que há momentos de palpação de pontos doloridos. Caso isso aconteça, os pesquisadores se comprometem à prestar o atendimento que se fizer necessário.Você poderá sentir dor durante as avaliações, pois serão solicitadas aberturas e fechamentos repetidos da boca. Porém, essa é uma importante medida clínica que mostrará alterações importantes do seu quadro, visto que a limitação da abertura da boca é relevante nesses casos.A avaliação cinemática pode ser um pouco desconfortável por causa do aparato de aço inoxidável acoplado à arcada dentária inferior, mas ela será realizada apenas duas vezes e da forma mais rápida possível para que o desconforto seja reduzido. As fitas utilizadas para fixação dos marcadores são hipoalérgicas e descartáveis, não havendo perigo de irritação da pele e contaminação. O adesivo cirúrgico que acopla o aparato de aço inoxidável é estéril e descartável para evitar contaminação, e o aparato será lavado e desinfetado entre uma avaliação e outra.Como benefícios relata que "Esses resultados podem ser importantes para definição da abordagem no tratamento da DTM, uma vez que se a hipótese apresentada for confirmada, esse resultado fortalecerá a abordagem baseada na biomecânica dos segmentos e ainda, poderá ser revisto uma forma de criar uma especificidade maior do tratamento, abordando com mais ênfase o ponto específico de cada patologia."

Comentários e Considerações sobre a Pesquisa:

O projeto de pesquisa possui relevância à área em questão.O cronograma foi corrigido e tem previsão de coleta de dados para outubro/2016.

Considerações sobre os Termos de apresentação obrigatória:

A folha de rosto datada e assinada pelo pesquisador e responsável pela instituição.O TCLE está adequado de acordo com a Resolução nº 466/2012.

Recomendações:

Nada a declarar. As recomendações foram atendidas pelo pesquisador responsável.

Conclusões ou Pendências e Lista de Inadequações:

Projeto aprovado.

Considerações Finais a critério do CEP:

O Comitê de Ética em Pesquisa (CEP) em Seres Humanos recomenda que os pesquisadores responsáveis consultem as normas do CEP e a resolução nº 466 de 2012, disponíveis na página da Plataforma Brasil em caso de dúvidas.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_569829.pdf	05/10/2016 21:40:35		Aceito
Folha de Rosto	Folha_Rosto_Bruno_Gruninger.pdf	05/10/2016 20:12:48	Bruno Leonardo da Silva Grüninger	Aceito
Outros	CEP_Bruno.doc	17/02/2016 16:04:09	Bruno Leonardo da Silva Grüninger	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Bruno.doc	17/02/2016 16:02:03	Bruno Leonardo da Silva Grüninger	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_versao_completa.doc	17/02/2016 16:01:35	Bruno Leonardo da Silva Grüninger	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

SAO CARLOS, 24 de Outubro de 2016

Assinado por:
Ricardo Carneiro Borra
(Coordenador)

Anexo I

Confirmação de Submissão do Artigo no periódico *Journal of Biomechanics*

28/01/2017 Gmail - Submission Confirmation

Gmail **Bruno Grüninger <brunogruninger@gmail.com>**

Submission Confirmation

1 mensagem

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Dear Mr. Grüninger,

Your submission entitled "How do jaw and head movements occur in TMD patients and healthy subjects?" has been received by the Journal of Biomechanics.

You will be able to check on the progress of your paper by logging on to EES as an author. The URL is https://ees.elsevier.com/bm/.

Your manuscript will be given a reference number once an Editor has been assigned.

Thank you for submitting your work to this journal.

Kind regards.

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