This is the Accepted Manuscript version of: Ballenberger, N. and von Piekartz, H. and Danzeisen, M. and Hall, T. 2017. Patterns of cervical and masticatory impairment in subgroups of people with temporomandibular disorders–an explorative approach based on factor analysis. Cranio. DOI: 10.1080/08869634.2017.1297904.

Patterns of Cervical and Masticatory Impairment in Subgroups of People with Temporomandibular Disorders–an Explorative Approach Based on Factor Analysis

Patterns of Cervical and Masticatory Impairment in Subgroups of People with Temporomandibular Disorders–an Explorative Approach Based on Factor Analysis

Abstract

Objectives

To identify clinical patterns of impairment affecting the cervical spine and masticatory systems in different subcategories of TMD by an explorative data driven approach.

Methods

For this observational study 144 subjects were subdivided according to Research Diagnostic Criteria for Temporomandibular Disorders into: healthy controls, temporomandibular joint (TMJ) signs without symptoms, TMJ affected, temporomandibular muscles affected, or TMJ and muscles affected. Factor analysis was applied to cervical spine and masticatory data while linear regression was applied to characterize clinical patterns in subgroups.

Results

Factor analysis identified five clinical dimensions which explained 59% of all variance: mechanosensitivity, cervical movement, cervical and masticatory dysfunction, jaw movement, and upper cervical movement. Regression analysis identified different clinical dimensions in each TMD subgroup.

Conclusion

Distinct clinical patterns of cervical spine and masticatory function were found among subgroups of TMD, which has clinical implications for therapeutic management.

Factor analysis, subgroup, TMD, cervical, explorative

Introduction

Temporomandibular disorder (TMD) is an umbrella term for structural and functional disorders related to the masticatory muscles and/or the temporomandibular joint (TMJ) with or without clinical signs and symptoms (1). It is the second most common cause of orofacial pain following dental pain (2). The prevalence of signs and symptoms related to TMD ranges widely, reported as low as 1% and as high as 75%, affecting more women and younger people which is uncommon for chronic pain conditions (2–6). The inconsistent epidemiological data is assumed to be a result of different unstandardized and heterogeneous diagnostic criteria used in the studies to define TMD and its symptoms (2, 7). The major clinical signs and symptoms associated with TMD are pain both local and referred into the temporal region of the head, lower face and neck, as well as clicking sound's, reduced and painful mouth opening, and bruxism (8–10). However, not all individuals diagnosed with TMD have symptoms (11) and thus it is estimated that only 3% of people with signs of TMD seek medical aid (10).

Biological as well as psychological aspects are assumed to be factors in the development of TMD (12). As a consequence, according to Research Diagnostic Criteria/TMD (RDC/TMD), classification of TMD will include physical or psychological diagnoses. Under physical diagnosis, patients are classified into muscle disorders and/or disc displacements and/or arthralgia, osteoarthritis or osteoarthrosis (1, 6, 13). The importance of diagnosis is to identify the appropriate management strategy from the broad spectrum of therapies described for this condition.

Within the contributing factors to TMD the cervical spine is considered to play a crucial role (14). Studies show anatomical and pathophysiological interactions between the

cervical spine and TMJ region (15–21). For example, people with TMD show higher prevalence and one-year-incidence for neck pain than those without TMD (20, 22). Furthermore, it has been demonstrated that the neck disability index is highly correlated with the jaw function scale (23). Studies have also demonstrated the influence of various head and neck postures on the masticatory muscles and their mechanosensitivity (18, 24). Additionally, there is some evidence that cervical dysfunction is the consequence of TMD. As such, various authors describe a positive effect of orofacial therapy (21, 25) on the function of the cervical spine. Yet, a clear causal relationship remains unclear.

Despite this, there is little high quality research evidence that has investigated the relationship between cervical dysfunction and TMD. Furthermore, according to the author´s knowledge, there are no studies investigating whether subgroups of TMD show distinct patterns of cervical and masticatory impairment. Finally, studies are lacking that give a comprehensive picture of the interaction between the cervical spine and the TMJ.

Consequently, the aim of this study is to describe and perform an extensive analysis in a study sample consisting of individuals classified into five subgroups according to physical diagnostic criteria of RDC/TMD. Subgroups of TMD are characterized with respect to patterns of impairment based on clinical and functional measurements associated with the masticatory and cervical systems. Therefore, instead of testing predefined, clinically driven hypotheses (which is the common way), this study uses an explorative data driven approach based on factor analysis. More detailed knowledge of clinical patterns of cervical and masticatory impairment among subgroups of TMD may ultimately direct management and thereby improve therapeutic outcomes.

Methods

Participants

For this observational study, subjects were recruited from physiotherapy practices in Northern Germany by information flyers. Subjects were evaluated for inclusion by a clinical expert with 15 years of experience managing orofacial pain according to the following criteria: (1) age at least 18 years, (2) score of less than 3 on the modified *Chronic Grade Pain Scale* (26–29) indicating chronic condition status , (3) conversant in the German language, (4) score of more than 3 measured on the CONTI questionnaire suggesting evidence of TMD (30).

Subjects acting as controls were selected from the same environment if they met the following criteria: (1) age at least 18 years, (2) conversant in the German language, (3) score of ≤ 3 measured by the CONTI questionnaire. Subjects were excluded if they had (1) a history of surgery or fractures in the neck and jaw or (2) neurologic deficits or (3) pain at night or other red flags or (4) were currently undergoing orthodontic treatment. Prior to participation, subjects gave written informed consent. The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee of the University of Applied Science Of Osnabrück.

For further stratification subjects were subdivided according to RDC/TMD. Therefore the presence of painful and restricted mouth opening, painful masticatory muscles on palpation, and TMJ sounds were assessed. These criteria are designed to define the subgroup of TMD. (31). As a consequence, patients with TMD (CONTI > 3) were subdivided into group “Arthogen” when joint disorders were present, group ”Myogen” when myofascial disorders were present, or into group “Mixed” when both joint disorders and myofascial disorders were present. Subjects acting as controls (CONTI ≤

3) were subdivided into group “Controls” having no TMD signs or pain or group “Just signs” having TMD signs that are not clinically relevant based on the Conti scale (30). Consequently, five subgroups were investigated with different diagnoses of TMD. We proposed that the “Mixed“ group would be the most severe as they had both joint disorders and myofascial involvement.

Functional measurements

The TMJ and the cervical spine were examined and measured separately by two clinically experienced physiotherapists who had 8 hours intensive training in the management of orofacial disorders. The investigator who executed the neck measurements was blind to subjects TMD subgroup classification.

TMJ Region

Range of motion

Measurements of TMJ range of motion (ROM) included mouth opening, active lateral shift of the jaw to both sides as well as active backward and forward movement of the jaw. Inter- and Intra-rater reliability has been shown to be moderate to excellent for these measurements.

Mechanonsensitivity

Mechanosensitivity of the Masseter and Temporalis muscles was determined by measuring pressure pain threshold (PPT) using an algometer (*Wagner instruments, Force dial FDK 10*). Pressure was applied at a constant rate of approximately 1 kg/cm2/s until subjects reported the point when the sensation changed from pressure to pain. Two readings were taken over each site and each muscle and averaged for analysis. PPT has been shown to be a valid and reliable method for measuring mechanosensitivity (32–34).

CONTI

The Conti questionnaire (30) was used for assessing TMD symptoms. This scale comprises ten questions concerning typical TMD features and has a score from 0, indicating no clinically relevant TMD, to 23. Prior to the examination subjects were asked whether they suffered from pain in the masticatory and cervical region.

PAIN

Pain was graded according to the Colored Analogue Scale (CAS) from 0 to 10. The CAS has high reproducibility (35).

Cervical spine

ROM

Active cervical ROM in all planes (flexion, extension, lateral flexion, and rotation) was measured by the Cervical ROM (CROM) device (36, 37). Maximum angles within comfortable limits were recorded. The CROM device is described as valid and reliable (36, 38, 39).

Mechanosensitivity

Mechanosensitivity of Upper Trapezius and Obliquus Capitis Inferior muscles were determined by measuring PPT using the method described above.

Neck disability index

The Neck disability index (NDI) was used to assess neck related disability and comprises 10 self-report questions covering activities of daily living, concentration and pain. The scale ranges from 0 (no pain and disability) to 50 (severe pain and disability) and has been shown to have good to excellent psychometric properties (40, 41).

Flexion-Rotation Test

147 Upper cervical rotation in end-range flexion (FRT) (42, 43) was recorded using a digital
148 goniometer (Halo Medical Device), while pain during the FRT was recorded by the CAS.
149 *Cranio-cervical Flexion-Test*
150 The Cranio-cervical Flexion-Test (CCFT) was used to measure endurance of the cervical
151 deep flexor muscles (44, 45) evaluated using a pressure biofeedback device
152 (*Chattanooga, USA*) according to a reliable procedure described by Hudswell (46–48).
153 *Number of cervical signs*
154 Palpation of the three upper cervical spine motion segments was conducted to assess
155 segmental mobility and pain. The number of symptomatic findings were aggregated
156 and termed “cervical signs”. This procedure has good reliability (49).
157 All measurements are summarized in Table S1 available online.
158 ***Analysis***
159 All statistical analysis was performed with R (50) including the psych package (51).
160 Analysis of variance and chi^2 was used to test for differences in baseline characteristics
161 between subgroups of participants. P-values < 0.05 were considered significant. The
162 basis of our analysis strategy was as follows: Rather than confirming whether clinically
163 driven predefined clinical patterns are present among subjects with TMD, we
164 performed a data driven explorative analysis strategy in order to identify clinically
165 relevant patterns among subgroups of individuals with TMD. Therefore we conducted
166 five steps including factor analysis and linear regression analysis.
167 Step 1: Factor analysis was used as a dimension reduction method. Measured variables
168 were condensed to a reduced number of factors that would still contain the majority
169 of the information from the original data. The dimensionality of the data was assessed,
170 where each factor represents a clinical dimension which was characterized with

171 respect to a clinical meaning. The appropriate number of relevant clinical dimensions
172 was established by applying the Very Structure Criterion (52) and the Parallel Analysis
173 Criterion (53) as implemented in the psychological package. Where inconsistency of
174 the statistical solutions was detected the more interpretable solution with respect to
175 clinical meaning was selected. The amount of information (variance) that is captured
176 by each of extracted factors was calculated by determining their eigenvalues.
177 Step 2: graphical descriptive means were used to assess the ability of the data to
178 discriminate people with TMD from controls in general. A scatterplot representing
179 each individual´s score for each pair of factors was constructed demonstrating the
180 general clinical relevance of the identified dimensions.
181 Step 3: the extracted factors (clinical dimensions), were interpreted with respect to a
182 clinical and functional meaning. Therefore, all measured variables were correlated
183 with the extracted factors. Their correlation coefficients represent their loadings on
184 the factors. By inspecting the correlation coefficients of each measured variable with
185 each factor the contribution of each variable to the respective factor was evaluated. As
186 a consequence, the clinical meaning of the factors was interpreted. In order to
187 facilitate interpretation, the factor solution was rotated before calculating the
188 correlation structure, in our case by Varimax rotation. Conceptually, the factors have
189 the function of summary variables of the underlying clinical dimension. The score of
190 each individual on each factor was calculated. As a consequence, it was possible to
191 quantify each person´s score on the respective clinical dimension, i.e. a low/high
192 person´s score represents a low/high summary score of the respective clinical
193 dimension.

Step 4: subgroup characterization was performed with respect to the clinical dimensions. Therefore, we aimed to determine to what extent each of the TMD subgroups was affected with respect to the respective clinical dimension. To do so we conducted the analysis with both the extracted factors, representing the clinical dimensions as summary variables, and with the original variables contributing to the respective clinical dimensions. For this purpose we used linear regression with subgroup membership as independent variables and all variables standardized (Mean=0, SD=1). Results are given as standardized mean differences and interpreted as effect sizes according to Cohen (<0.2 no effect, 0.2-0.5 small effect, 0.5-0.8 moderate, 0.8>large effect) (56). This approach is analogous to meta- analysis in order to be able to compare results across outcomes with different units.

Step 5: Finally, a summary was generated of how the TMD subgroups were characterized with respect to the identified clinical dimensions. Also, here the strength of clinical impairment in each dimension was given as interpretable values according to Cohen. Hence, the clinical pattern of each subgroup was presented indicating which clinical dimension was affected to which extent.

The quality of the factor analysis models was assessed using Bartlett's test for sphericity (54) and the Kaiser-Meyer-Olkin test (55). For regression analysis, variables that assessed bilateral measurements were combined to one variable by calculating the mean of left and right sides as no significant side differences were present. Additionally, we added age and gender as covariates into regression models as potential confounders. If p-values of confounders according to t-statistics were >0.1, or changed the estimate less than 10%, those variables were withdrawn from the model.

Results

Of 175 people assessed for inclusion 144 participants met the study criteria. These people were divided into five subgroups and characterized with respect to clinical patterns of impairment based on clinical and functional measurements from the TMJ and cervical spine as depicted in the work flow diagram in Figure 1.

Figure 1:

Baseline characteristics are summarized in Table 1.

Bartlett's Test of Sphericity was highly significant (Chi square = 1513.003, $P < 0.001$) and the KMO test was 0.82, supporting the suitability of the data for factor analysis.

Step 1 clinical dimensionality of data: We extracted 5 independent factors by factor analysis representing five clinical dimensions. In total, the five dimensions explained 59% of the total variance (dimension 1 - 23%, dimension 2 - 13%, dimension 3 - 8%, dimension 4 - 8%, and dimension 5 - 5%).

Step 2 general overview of distinction between subjects with TMD and controls: Figure 2 shows the scores of all individuals on each of the five factors, i.e. on each clinical dimension. Each scatter plot shows each individual´s score of a pair of dimensions. E.g. the very left top plot depicts scores of dimension 1 on the x-axis and scores of dimension 2 on the y-axis. Black Cs represent the control group including the control group with symptoms of TMD. Grey Ts represent the TMD group including sub-groups "Arthrogen", "Myogen" and "Mixed". Plots of dimension 1 to dimension 4 show, albeit some overlap of the dots, that the scores of subjects with TMD are separate to the scores of controls indicating that subjects with TMD generally possess distinct underlying clinical patterns compared to controls. This especially holds true for the third dimension. Factor 5 suggests no distinct pattern between the groups.

Figure 2:

Step 3 Characterization of clinical dimensions. In Table 2 the factor loadings of each measured variable are listed. The key variables of each independent factor, i.e. clinical dimension, are marked in grey. The values are the correlation coefficients of each measured variable with each factor. This allows the clinical and functional interpretation of the clinical dimensions. As a consequence, factor 1 represents the clinical dimension “mechanosensitivity” as it includes all variables measuring mechanosensitivity of muscle sites in the masticatory and cervical region as well as the variable “cervical signs” (coefficient range: 0.64-0.89). Factor 2 is characterized by the clinical dimension cervical ROM which includes movement in all directions (coefficient range: 0.54-0.81). Factor 3 comprises both cervical and masticatory dysfunction measured by the NDI and CONTI questionnaires, as well as the presence of pain when performing the FRT (coefficient range: 0.47-0.72). As a consequence we called this clinical dimension “Cervical/masticatory dysfunction and pain”. Factor 4 represents the clinical dimension “jaw movements” which includes TMJ movement in all directions (coefficient range: 0.43-0.7). The last factor consists of the clinical dimension FRT ROM and the CCFT (coefficient range: 0.45-0.78).

Table 2:

Step 4 Characterization of TMD subgroups: Figure 3 shows the pairwise differences between each of the subgroups compared to the Control group with respect to all clinical dimensions including all contributing variables. Linear regression was used for this analysis. The first variable of each column and each pairwise comparison (summary variable) represents the extracted factors by factor analysis and is considered as the summary variable of each corresponding clinical dimension for the respective group comparison. Below each summary variable the contributing variables

to each clinical dimension, according to Table 2, are listed. The effects of the subgroups “Mixed”, “Myogen”, “Arthrogen“ and “Just signs” in comparison to the reference group (control group without TMD signs) are presented as standardized mean differences (SMD) and ±95% Confidence Intervals. It allows interpretation of the coefficients in effect size. In the dimension “mechanosensitivity” the overall effect size represented by its summary variable for the comparison “Mixed” group vs control group is -0.83 [-1.32;-0.38] suggesting a large effect. In others words this means that in general, mechanosensitivity of the “Mixed“ group is greatly elevated when compared to “Controls“. This effect is consistent across all single variables of the clinical dimension “mechanosensitivity”. The variables range from -0.77 for Temporalis muscle to 0.92 for “cervical signs”. The second largest effect size with respect to the clinical dimension “mechanosensitivity” is observed between the “Myogen“ group and the control group with an effect size of -0.39 [-0.96;0.21]. In the remaining two groups the effect size is below -0.25. For the dimension “cervical mobility” a similar pattern is observed. Also here the “Mixed“ group has the most reduced cervical ROM with an effect size of -0.58 [-1.06;-0.10] followed by the “Myogen“ group having an effect size of -0.38 [-0.99;0.23]. The most affected direction in both the “Mixed“ and “Myogen“ group is extension with effect sizes of -0.69 [-1.16;-0.23] and -0.63 [-1.19;-0.06] respectively. The least affected variable in both groups is flexion (effect size in the “Mixed“ group: -0.27[-0.78;0.24], effect size in the “Myogen“ group: -0.36 [-0.98;0.26]).

Dimension “Cervical/masticatory dysfunction and pain”, is similarly impaired in all subgroups apart from “Just signs” group. The large effect sizes of the summary variables range from -0.94[-0.50;-1.38] in the “Mixed“ group to -1.28 [-0.72;-1.83] in

290 the “Myogen“ group. The effect sizes for the single variables CONTI, NDI and pain
291 during FRT range in the three affected subgroups between -0.78 [-0.33;1.20] and -1.69
292 [-1.35;-2.04]. Acute pain is only present in the “Myogen“ group with an moderate
293 effect size of -0.71 [-0.27;-1.15]. Dimension 4 ”jaw movement” is restricted across all
294 subgroups with moderate effects sizes of the summary variables from -0.54 [-
295 1.15;0.08] in the “Myogen“ group to -0.77[-1.27;-0.26] in the “Mixed“ group. Finally,
296 the last dimension has no clinical meaning for any of the subgroups indicated by effect
297 sizes lower than 0.20.
298 Figure 3:
299 Step 5 summary of clinical patterns in TMD subgroups:
300 In Table 3 the clinical patterns with respect to the cervical and masticatory systems of
301 the subgroups are depicted. Arrows indicate to which extent a subgroup is restricted in
302 each clinical dimension and represent effect sizes stemming from the summary
303 variables of each clinical dimension shown in figure 3. One arrow is a small effect, two
304 arrows a medium effect and three arrows a large effect. As a consequence, the
305 “Mixed“ group is the most affected group, with moderate to large limitations in the
306 dimensions “mechanosensitivity”, “cervical ROM”, “cervical and masticatory
307 dysfunction and pain” and “jaw movement”. The “Myogen“ group is also affected in
308 the same dimensions, however, less with respect to “mechanosensitivity” and “cervical
309 ROM”. Groups “Arthrogen“ and “Just signs“ have only medium to large limitations in
310 dimensions “cervical and masticatory dysfunction and pain” and jaw movement.
311 Table 3:

312 **Discussion**

In this explorative data driven analysis five independent clinical dimensions were identified based on 28 functional measurements from the cervical spine and masticatory systems using factor analysis with varimax rotation and linear regression analysis. These dimensions are interpreted as mechanosensitivity, cervical ROM, cervical and masticatory dysfunction, jaw movement and upper cervical ROM/endurance. The five factors explain 59% of all variance. Furthermore, the 144 subjects divided into five subgroups according to RDC/TMD were characterized with respect to the five clinical dimensions. The “Mixed“ group is the most affected group with moderate to large limitations in all dimensions followed by the “Myogen“ group with limitations in the same dimensions, however, less with respect to mechanosensitivity and cervical ROM. Groups “Arthrogen“ and “Just signs“ show medium to large limitations only concerning cervical and masticatory dysfunction and jaw movement. A clear dose response relationship was observed indicating that subjects with a diagnosis of TMD in two aspects (myogenic and arthrogenic) are most affected.

The main advantage of this explorative data driven approach is that it revealed clinical patterns that were quite unexpected and probably would have not been identified by a clinically driven approach. This is illustrated by two findings as examples: Firstly, the clinical dimension “mechanosensitivity” consisted of variables measuring mechanosensitivity at all muscle sites, not just over cervical or masticatory muscles. From the clinical point of view one might have expected two distinct dimensions, namely “cervical mechanosensitivity” and “masticatory mechanosensitivity”. However, due to the high correlation structure the analysis revealed that the two regions are highly interrelated with respect to mechanosensitivity and may not be seen as

clinically different problems. On the one hand this finding confirms the fact that subjects with TMD suffer from referred pain into the neck region. On the other hand, this finding perhaps suggests that patients with TMD are dominated by mechanism(s) of central sensitization with associated areas of secondary hyperalgesia.

A similar surprising result was seen for the variables NDI and CONTI which were found to occur together in one dimension. Even though it is known (25, 57–59) that these two variables are correlated, it was surprising that both variables were related so much to each other that they loaded equally highly on the same factor. From the clinical point of view one might have expected that the variable NDI would cluster together with variables measuring neck muscle mechanosensitivity or cervical ROM. Additionally, the CONTI might be expected to cluster together with jaw movements or variables measuring masticatory muscle mechanosensitivity .

In this study, ROM of the upper cervical spine together with endurance of the neck flexors were not found to have any clinical relevance for any subgroup. (60) This is in contrast to previous studies showing evidence of altered upper cervical spine ROM and muscle performance in TMD overall and in specific sub-groups of people with TMD (16, 59–61). The difference could be explained by the small sample size in some studies (60, 61), but that was not the case in the study by Armijo-Olivo and Magee (59). Further studies are required to elucidate this.

Less surprising is that fact that the “Mixed“ group was the most affected group. One might expect this finding from the clinical point of view as well.

A further advantage of the present study is the use of the extracted factors as summary variables of each identified clinical dimension. In that way a summary score of each clinical dimension could be calculated for each individual. As a consequence

high/low individual scores mean large/low limitations in the respective dimension. The clinical relevance of this information requires careful consideration. These results confirm that patient's with TMD are not homogenous, different subgroups exist with different clinical presentations. Each subgroup may therefore require a different form of intervention to address the underlying mechanisms.

Clinical Implications

The findings of this study have clinical implications for practice. In general there is a need to subgroup patients with TMD as they have distinct functional profiles with respect to the cervical and masticatory systems. Typically, this kind of procedure is conducted in daily clinical practice by therapists where individuals are categorized based on a comprehensive clinical evaluation in order to initialize individually tailored therapy and patient management programs (63). Similar broad-based evaluative approaches are undertaken in patients with low back pain (64). Furthermore it has been shown that sub-classification based therapy is more effective than standard protocols (65–68).

The fact that NDI and CONTI are highly interrelated to form one clinical dimension suggests that when patients present with high levels of impairment of TMD, high levels of disability of the cervical region should also be expected. This holds true across all subgroups of TMD. As a consequence, management should address impaired domains detected by the NDI and CONTI.

It would appear reasonable to suggest that for patients with arthrogenic and myogenic features of TMD, management should address mechanosensitivity of masticatory and neck muscles. However, the underlying pain mechanism in this dimension are indicative of central sensitization which requires a different management approach.

Impaired mechanosensitivity seems to be less likely among patients with myogenic TMD and almost nonexistent in patients with arthrogenic TMD.

Cervical ROM is another clinical dimension that seems to be problematic and needs attention in clinical practice in patients with „"Mixed" TMD, but less so in myogenic and arthrogenic TMD. In contrast, restricted ROM of the TMJ is similarly present across all TMD subgroups.

In general, it can be noted that in none of the clinical dimensions does a single variable stand out that requires specific attention. For example, in the clinical dimension mechanosensitivity, there is not a single muscle alone that is affected. All muscles are equally affected. The same holds true for cervical ROM, where it is not a single movement but all planes that are equally affected.

Strengths

The strength of this paper is the application of factor analysis as an explorative data driven approach to characterize predefined subgroups with respect to until now unknown clinical patterns. This approach is unusual and not commonly applied. However, it has yielded unexpected but clinically meaningful and relevant implications. This was only possible due to a large sample size and detailed and extensive measurements which is uncommon in studies of TMD.

However, there are other statistical approaches that perform subgroup classification based on data modelling. Common statistical techniques include among others cluster or latent class analysis. Instead of predefining subgroups based on clinical diagnosis these techniques create subgroups based on the observed data. Consequently, built classes are interpreted and analyzed with respect to clinical relevance (69).

Limitations

A potential weakness of this study is the exclusion of patients with chronic disease. As a result, it is not possible to draw any conclusions regarding those patients. Furthermore, this study did not include psychosocial aspects in the factor analysis. In addition, in an attempt to control for potential confounders it was not possible to use a matched case controlled design. Matched case controlled designs allow more efficient statistical analysis approaches resulting in more power. Finally, in order to disentangle the temporal relationship between onset of cervical spine and masticatory complaints, a longitudinal study designs is necessary.

For the purpose of validation it is essential to replicate the study findings in further research. The presence of the identified clinical dimensions and patterns among subgroups of TMD need to be confirmed by confirmatory factor analysis in other samples.

Conclusion

An explorative data driven analysis was used for identifying clinical patterns among subgroups of TMD. These results have implications for clinical decision making and therapeutic management in patients with TMD. As a consequence, it is proposed that subgrouping patients with TMD is essential as these show distinctly different clinical patterns with respect to the masticatory and cervical spine systems in order to improve outcomes.

References

1. Dworkin SF, Huggins KH, LeResche L, Korff M v., Howard J, Truelove E, Sommers E. Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls. J Am Dent Assoc 1990;120(3):273. eng.

2. Manfredini D, Guarda-Nardini L, Winocur E, Piccotti F, Ahlberg J, Lobbezoo F. Research diagnostic criteria for temporomandibular disorders: a systematic review of axis I epidemiologic findings. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112(4):453. eng. doi:10.1016/j.tripleo.2011.04.021.

3. Johansson A, Unell L, Carlsson GE, Soderfeldt B, Halling A. Gender difference in symptoms related to temporomandibular disorders in a population of 50-year-old subjects. J Orofac Pain 2003;17(1):29. eng.

4. Macfarlane TV, Blinkhorn AS, Davies RM, Kincey J, Worthington HV. Oro-facial pain in the community: prevalence and associated impact. Community Dent Oral Epidemiol 2002;30(1):52. eng.

5. Shaffer SM, Brismee J-M, Sizer PS, Courtney CA. Temporomandibular disorders. Part 1: anatomy and examination/diagnosis. J Man Manip Ther 2014;22(1):2. eng. doi:10.1179/2042618613Y.0000000060.

6. LeResche L. Epidemiology of temporomandibular disorders: implications for the investigation of etiologic factors. Crit Rev Oral Biol Med 1997;8(3):291. eng.

7. Poveda Roda R, Bagan JV, Diaz Fernandez, Jose Maria, Hernandez Bazan S, Jimenez Soriano Y. Review of temporomandibular joint pathology. Part I: classification, epidemiology and risk factors. Med Oral Patol Oral Cir Bucal 2007;12(4):E292-8. eng.

8. Svensson P, Graven-Nielsen T. Craniofacial muscle pain: review of mechanisms and clinical manifestations. J Orofac Pain 2001;15(2):117. eng.

9. Thilander B, Lennartsson B. A study of children with unilateral posterior crossbite, treated and untreated, in the deciduous dentition--occlusal and skeletal characteristics of significance in predicting the long-term outcome. J Orofac Orthop 2002;63(5):371. eng;ger. doi:10.1007/s00056-002-0210-6.

10. De Kanter, R J, Truin GJ, Burgersdijk RC, Van 't Hof, M A, Battistuzzi PG, Kalsbeek H, Kayser AF. Prevalence in the Dutch adult population and a meta-analysis of signs and symptoms of temporomandibular disorder. J Dent Res 1993;72(11):1509. eng.

11. Gesch D, Bernhardt O, Kocher T, John U, Hensel E, Alte D. Association of malocclusion and functional occlusion with signs of temporomandibular disorders in adults: results of the population-based study of health in Pomerania. Angle Orthod 2004;74(4):512. eng. doi:10.1043/0003-3219(2004)074<0512:AOMAFO>2.0.CO;2.

12. Armijo Olivo S, Magee DJ, Parfitt M, Major P, Thie, Norman M R. The association between the cervical spine, the stomatognathic system, and craniofacial pain: a critical review. J Orofac Pain 2006;20(4):271. eng.

13. Leeuw de R, Klasser GD. Orofacial pain. Guidelines for assessment, diagnosis, and management. Chicago: Quintessence Publishing Co, 2013.

14. Bogduk N. Cervicogenic headache: anatomic basis and pathophysiologic mechanisms. Curr Pain Headache Rep 2001;5(4):382. eng.

15. Rocabado M. Biomechanical relationship of the cranial, cervical, and hyoid regions. J Craniomandibular Pract 1983;1(3):61. eng.

16. Laat A de, Meuleman H, Stevens A, Verbeke G. Correlation between cervical spine and temporomandibular disorders. Clin Oral Investig 1998;2(2):54. eng.

17. Xiong G, Matsushita M. Upper cervical afferents to the motor trigeminal nucleus and the subnucleus oralis of the spinal trigeminal nucleus in the rat: an anterograde and retrograde tracing study. Neurosci Lett 2000;286(2):127. eng.

18. Ballenberger N, Piekartz H v., Paris-Alemany A, La Touche R, Angulo-Diaz-Parreno S. Influence of different upper cervical positions on electromyography activity of the masticatory muscles. J Manipulative Physiol Ther 2012;35(4):308. eng. doi:10.1016/j.jmpt.2012.04.020.

19. Armijo-Olivo S, Silvestre RA, Fuentes JP, da Costa, Bruno R, Major PW, Warren S, Thie, Norman M R, Magee DJ. Patients with temporomandibular disorders have increased fatigability of the cervical extensor muscles. Clin J Pain 2012;28(1):55. eng. doi:10.1097/AJP.0b013e31822019f2.

20. Visscher CM, Lobbezoo F, Boer W de, van der Zaag, J, Naeije M. Prevalence of cervical spinal pain in craniomandibular pain patients. Eur J Oral Sci 2001;109(2):76. eng.

21. Piekartz H v., Hall T. Orofacial manual therapy improves cervical movement impairment associated with headache and features of temporomandibular dysfunction: a randomized controlled trial. Man Ther 2013;18(4):345. eng. doi:10.1016/j.math.2012.12.005.

22. Hoy DG, Protani M, De R, Buchbinder R. The epidemiology of neck pain. Best Pract Res Clin Rheumatol 2010;24(6):783. eng. doi:10.1016/j.berh.2011.01.019.

23. Olivo SA, Fuentes J, Major PW, Warren S, Thie, N M R, Magee DJ. The association between neck disability and jaw disability. J Oral Rehabil 2010;37(9):670. eng. doi:10.1111/j.1365-2842.2010.02098.x.

24. La Touche R, París-Alemany A, Piekartz H v., Mannheimer JS, Fernández-Carnero J, Rocabado M. The influence of cranio-cervical posture on maximal mouth opening and pressure pain threshold in patients with myofascial temporomandibular pain disorders. Clin J Pain 2011;27(1):48. eng. doi:10.1097/AJP.0b013e3181edc157.

25. Piekartz H v., Ludtke K. Effect of treatment of temporomandibular disorders (TMD) in patients with cervicogenic headache: a single-blind, randomized controlled study. Cranio 2011;29(1):43. eng. doi:10.1179/crn.2011.008.

26. Türp JC, Marinello CP. Schmerzfragebogen für Patienten mit chronischen orofazialen Schmerzen. Die Quintessenz 2002;2002(12):

27. Smith BH, Penny KI, Purves AM, Munro C, Wilson B, Grimshaw J, Chambers WA, Smith WC. The Chronic Pain Grade questionnaire: validation and reliability in postal research. Pain 1997;71(2):141. eng.

28. Elliott AM, Smith BH, Smith WC, Chambers WA. Changes in chronic pain severity over time: the Chronic Pain Grade as a valid measure. Pain 2000;88(3):303. eng.

29. John MT, Hirsch C, Reiber T, Dworkin SF. Translating the research diagnostic criteria for temporomandibular disorders into German: evaluation of content and process. J Orofac Pain 2006;20(1):43. eng.

30. Conti PC, Ferreira PM, Pegoraro LF, Conti JV, Salvador MC. A cross-sectional study of prevalence and etiology of signs and symptoms of temporomandibular disorders in high school and university students. J Orofac Pain 1996;10(3):254. eng.

31. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet J-P, List T, Svensson P, Gonzalez Y, Lobbezoo F, Michelotti A, Brooks SL, Ceusters W, Drangsholt M, Ettlin D, Gaul C, Goldberg LJ, Haythornthwaite JA, Hollender L, Jensen R, John MT, Laat A de, Leeuw R de, Maixner W, van der Meulen, Marylee, Murray GM, Nixdorf DR, Palla S, Petersson A, Pionchon P, Smith B, Visscher CM, Zakrzewska J, Dworkin SF. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Groupdagger. J Oral Facial Pain Headache 2014;28(1):6. eng. doi:10.11607/jop.1151.

32. Nussbaum EL, Downes L. Reliability of clinical pressure-pain algometric measurements obtained on consecutive days. Phys Ther 1998;78(2):160. eng.

33. Grossi DB, Chaves TC, Goncalves MC, Moreira VC, Canonica AC, Florencio LL, Bordini CA, Speciali JG, Bigal ME. Pressure pain threshold in the craniocervical muscles of women with episodic and chronic migraine: a controlled study. Arq Neuropsiquiatr 2011;69(4):607. eng.

34. Persson AL, Brogardh C, Sjolund BH. Tender or not tender: test-retest repeatability of pressure pain thresholds in the trapezius and deltoid muscles of healthy women. J Rehabil Med 2004;36(1):17. eng.

35. Bulloch B, Garcia-Filion P, Notricia D, Bryson M, McConahay T. Reliability of the color analog scale: repeatability of scores in traumatic and nontraumatic injuries. Acad Emerg Med 2009;16(5):465. eng. doi:10.1111/j.1553-2712.2009.00404.x.

36. Youdas JW, Carey JR, Garrett TR. Reliability of measurements of cervical spine range of motion--comparison of three methods. Phys Ther 1991;71(2):98-104; discussion 105-6. eng.

37. Zito G, Jull G, Story I. Clinical tests of musculoskeletal dysfunction in the diagnosis of cervicogenic headache. Man Ther 2006;11(2):118. eng. doi:10.1016/j.math.2005.04.007.

38. Audette I, Dumas J-P, Côté JN, De Serres, Sophie J. Validity and between-day reliability of the cervical range of motion (CROM) device. J Orthop Sports Phys Ther 2010;40(5):318. eng. doi:10.2519/jospt.2010.3180.

39. Tousignant M, Duclos E, Lafleche S, Mayer A, Tousignant-Laflamme Y, Brosseau L, O'Sullivan JP. Validity study for the cervical range of motion device used for lateral flexion in patients with neck pain. Spine (Phila Pa 1976) 2002;27(8):812. eng.

40. Vernon H. The Neck Disability Index: state-of-the-art, 1991-2008. J Manipulative Physiol Ther 2008;31(7):491. eng. doi:10.1016/j.jmpt.2008.08.006.

41. Cramer H, Lauche R, Langhorst J, Dobos GJ, Michalsen A. Validation of the German version of the Neck Disability Index (NDI). BMC Musculoskelet Disord 2014;1591. eng. doi:10.1186/1471-2474-15-91.

42. Takasaki H, Hall T, Oshiro S, Kaneko S, Ikemoto Y, Jull G. Normal kinematics of the upper cervical spine during the Flexion-Rotation Test - In vivo measurements using magnetic resonance imaging. Man Ther 2011;16(2):167. eng. doi:10.1016/j.math.2010.10.002.

43. Hall T, Robinson K. The flexion-rotation test and active cervical mobility--a comparative measurement study in cervicogenic headache. Man Ther 2004;9(4):197. eng. doi:10.1016/j.math.2004.04.004.

44. Cagnie B, D'Hooge R, Achten E, Cambier D, Danneels L. A magnetic resonance imaging investigation into the function of the deep cervical flexors during the performance of craniocervical flexion. J Manipulative Physiol Ther 2010;33(4):286. eng. doi:10.1016/j.jmpt.2010.03.010.

45. Falla DL, Jull GA, Hodges PW. Patients with neck pain demonstrate reduced electromyographic activity of the deep cervical flexor muscles during performance of the craniocervical flexion test. Spine (Phila Pa 1976) 2004;29(19):2108. eng.

46. Hudswell S, Mengersen M v., Lucas N. The cranio-cervical flexion test using pressure biofeedback: A useful measure of cervical dysfunction in the clinical setting? International Journal of Osteopathic Medicine 2005;8(3):98. doi:10.1016/j.ijosm.2005.07.003.

47. Jull G, Barrett C, Magee R, Ho P. Further clinical clarification of the muscle dysfunction in cervical headache. Cephalalgia 1999;19(3):179. eng.

48. James G, Doe T. The craniocervical flexion test: intra-tester reliability in asymptomatic subjects. Physiother Res Int 2010;15(3):144. eng. doi:10.1002/pri.456.

49. Hall T, Briffa K, Hopper D. The influence of lower cervical joint pain on range of motion and interpretation of the flexion-rotation test. J Man Manip Ther 2010;18(3):126. eng. doi:10.1179/106698110X12640740712293.

50. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing; 2014. Available from: http://www.R-project.org/.

51. William Revelle. psych: Procedures for Psychological, Psychometric, and Personality Research. Evanston, Illinois; 2014. Available from: http://CRAN.R-project.org/package=psych.

52. Revelle W, Rocklin T. Very simple structure: An alternative procedure for estimating the optimal number of interpretable factors. Multivariate Behavioral Research 1979;14(4):403.

53. Humphreys LG, Montanelli Jr., Richard G. An Investigation of the Parallel Analysis Criterion for Determining the Number of Common Factors. Multivariate Behavioral Research 2010;10(2):193. doi:10.1207/s15327906mbr1002_5.

54. Cohen J. A power primer. Psychological bulletin 1992;112(1):155.

55. Bartlett MS. The Effect of Standardization on a chi square Approximation in Factor Analysis. Biometrika 1951;1951(38):337.

56. Kaiser H. Analysis of factorial simplicity. sychometrika 1974;1974(39):31.

57. Silveira A, Gadotti IC, Armijo-Olivo S, Biasotto-Gonzalez DA, Magee D. Jaw Dysfunction Is Associated with Neck Disability and Muscle Tenderness in Subjects with and without Chronic Temporomandibular Disorders. Biomed Res Int 2015;2015512792. eng. doi:10.1155/2015/512792.

58. da Costa, Dayse Regina Alves, de Lima Ferreira, Ana Paula, Pereira, Thaís Alves Barreto, Porporatti AL, Conti, Paulo César Rodrigues, Costa YM, Bonjardim LR. Neck disability is associated with masticatory myofascial pain and regional muscle sensitivity. Arch. Oral Biol. 2015;60(5):745. eng. doi:10.1016/j.archoralbio.2015.02.009.

59. Armijo-Olivo S, Magee D. Cervical musculoskeletal impairments and temporomandibular disorders. J Oral Maxillofac Res 2013;3(4):e4. eng. doi:10.5037/jomr.2012.3404.

60. Grondin F, Hall T, Laurentjoye M, Ella B. Upper cervical range of motion is impaired in patients with temporomandibular disorders. Cranio 2015;33(2):91. eng. doi:10.1179/0886963414Z.00000000053.

61. Bevilaqua-Grossi D, Chaves TC, de Oliveira, Anamaria Siriani. Cervical spine signs and symptoms: perpetuating rather than predisposing factors for temporomandibular disorders in women. J Appl Oral Sci 2007;15(4):259. eng.

62. Weber P, Correa, Eliane Castilhos Rodrigues, Ferreira, Fabiana dos Santos, Soares JC, Bolzan, Geovana de Paula, Silva, Ana Maria Toniolo da. Cervical spine dysfunction signs and symptoms in individuals with temporomandibular disorder. J Soc Bras Fonoaudiol 2012;24(2):134. eng;por.

63. Piekartz H v. Kiefer, Gesichts- und Zervikalregion, Neuromuskuloskeletale Untersuchung, Therapie und Mangagement. 2nd ed. Stuttgart: Thieme; 2014. 600 p. (Physiofachbuch). ISBN: 3131392320.

64. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. Man Ther 2005;10(4):242. eng. doi:10.1016/j.math.2005.07.001.

65. Hill JC, Whitehurst DGT, Lewis M, Bryan S, Dunn KM, Foster NE, Konstantinou K, Main CJ, Mason E, Somerville S, Sowden G, Vohora K, Hay EM. Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomised controlled trial. The Lancet 2011;378(9802):1560. doi:10.1016/S0140-6736(11)60937-9.

66. Fersum KV, Dankaerts W, O'Sullivan PB, Maes J, Skouen JS, Bjordal JM, Kvåle A. Integration of subclassification strategies in randomised controlled clinical trials evaluating manual therapy treatment and exercise therapy for non-specific chronic low back pain: a systematic review. Br J Sports Med 2010;44(14):1054. eng. doi:10.1136/bjsm.2009.063289.

67. Foster NE, Mullis R, Hill JC, Lewis M, Whitehurst, David G T, Doyle C, Konstantinou K, Main C, Somerville S, Sowden G, Wathall S, Young J, Hay EM. Effect of stratified care for low back pain in family practice (IMPaCT Back): a prospective population-based sequential comparison. Ann Fam Med 2014;12(2):102. eng. doi:10.1370/afm.1625.

68. Slater SL, Ford JJ, Richards MC, Taylor NF, Surkitt LD, Hahne AJ. The effectiveness of sub-group specific manual therapy for low back pain: a systematic review. Man Ther 2012;17(3):201. eng. doi:10.1016/j.math.2012.01.006.

69. Depner M, Fuchs O, Genuneit J, Karvonen AM, Hyvarinen A, Kaulek V, Roduit C, Weber J, Schaub B, Lauener R, Kabesch M, Pfefferle PI, Frey U, Pekkanen J, Dalphin J-C, Riedler J, Braun-Fahrlander C, Mutius E v., Ege MJ. Clinical and epidemiologic phenotypes of childhood asthma. Am J Respir Crit Care Med 2014;189(2):129. eng. doi:10.1164/rccm.201307-1198OC.

643

644

645 Table S1 online: Functional measurements of TMJ region and cervical spine

646 Variables were used for identifying clinical patterns among TMD patients by explorative data analysis

Measurements	Description
Conti Questionnaire	Contains 10 questions that are related to problems originating from the temporomandibular region. Each question has three ranking options (0=none: 1=present: and 3=strong or bilateral). The likelihood of a CMD is divided into 4 subgroups: 4- 9, none: 9-14, minimal: 15-21, moderate: 21-23, strong
Colored Analogue Scale (CAS)	Pain intensity scale similar to the visual analogue scale transformed in an increasing colored line in mm that respresents the pain intensity
Range of motion of TMJ	Using a ruler of 15 cm, starting at 0, the active ROM of TMJ is measured including mouth opening, lateral shift, backward and forward movement of the jaw
Mechanosensitivity of cervical and masticatory muscles	The mechanical pressure pain threshold is assessed of the masticatory system and the neck mucles by a digital in kilogram force (Kgf). Muscles measured: Masseter, Temporalis, Upper Trapezius and Obliquus Capitis Inferior
Neck Disability Index (NDI)	A dimension-specific index that reflects “functional limitation” in neck disorders (includes 10 items (activities) with six different response options, ranging from “no disability” (0) to “complete disability.”(5) The total score is 50. A higher score indicates more pain and disability
Cervical Range of Motion (CROM)	Measurement of cervical spine flexion, extension, rotation and lateral flexion using an inclinometer

Cranial cervical Flexion Test (CCFT)	Measures the cervical flexor muscle synergy during upper cervical flexion. A pressure sensor positioned under the neck enables targeted increases in upper cervical flexion ROM by raising pressure in the sensor at 2 mm Hg increments from a baseline of 20, rising to 30mm Hg.
Flexon Rotation Test (FRT)	Passive rotation of the cervical spine in maximal flexion measured in supine. Subjective pain response and range of rotation is recorded.
N° of cervical signs	Palpation of the three upper cervical spine motion segments was to assess segmental mobility and pain. Score is sum of number of symptomatic findings.

647

648 Table 1: baseline characteristic of the study participants according to subgroups

	Healthy (n=21)	**Just signs (n=23)**	**Arthrogen (n=18)**	**Myogen (n=19)**	**Mixed (n=63)**	**p-Value**
Female sex: n (%)	11 (52%)	18(78%)	15 (84%)	15 (89%)	54 (83%)	0.045
Age in years: mean (SD)	33.15 (9.86)	32.61 (7.91)	35.11 (9.58)	31.11(8.55)	36 (13.61)	0.44
CONTI: mean (SD)	1.619 (1.15)	1.91 (0.99)	6.50 (2.55)	7.23 (3.33)	8.57 (3.59)	<0.0001
Mouth opening in mm: mean (SD)	46.95 (5.47)	42.34 (4.45)	42.61 (6.91)	46.52 (5.11)	42.30 (6.65)	0.005

649

650

651 Table 2: Factor loadings of measured variables

652 The table shows contribution of each measured variable to each identified dimension by means of
653 correlation coefficients. Grey shaded cells indicate high contribution. Based on correlation coefficients
654 clinical characterization of dimensions is carried out.

variables	**Factor 1** **"**mechano-sensitivity"	**Factor 2** "cervical ROM"	**Factor 3** "Cervical/mastic at. dysfunction and pain"	**Factor 4** "jaw movement"	**Factor 5** "ROM and endurance upp. cervical spine"
MS trap right	**0.88**	-0.13	-0.15	0.12	-0.02
MS trap left	**0.83**	-0.13	-0.28	0.03	-0.10
MS obliq right	**0.86**	-0.08	-0.16	0.04	0.09
MS obliq left	**0.89**	-0.04	-0.17	0.11	0.06
MS temp right	**0.85**	0.02	-0.01	-0.03	-0.10
MS temp left	**0.85**	0.06	-0.01	-0.03	0.02
MS mass right	**0.82**	0.16	0.00	0.00	0.09
MS mass left	**0.80**	0.12	0.06	0.07	0.10
Nr° of cervical signs	**-0.64**	-0.25	0.33	-0.14	-0.37
Flexion	-0.14	**0.54**	-0.05	0.18	0.04
Extension	0.10	**0.72**	-0.13	0.11	0.05
Lateralflex right	0.12	**0.77**	-0.08	0.00	0.11
Lateralflex left	0.08	**0.80**	-0.05	-0.10	0.08
Rotation right	-0.06	**0.67**	-0.13	0.13	0.05
Rotation left	-0.04	**0.81**	-0.08	0.13	0.10
pain acute	0.07	-0.13	**0.47**	0.11	0.11

NDI	-0.21	-0.28	**0.62**	-0.10	0.16
CONTI	-0.28	-0.16	**0.57**	-0.24	0.21
pain FRT right	-0.18	0.02	**0.72**	-0.01	-0.42
pain FRT left	-0.25	-0.08	**0.67**	-0.10	-0.29
mouth opening	0.20	0.22	0.17	**0.43**	-0.06
lateral shift left	-0.04	-0.03	0.03	**0.70**	-0.01
lateral shift right	-0.09	0.10	-0.25	**0.69**	0.04
Forward movement	0.08	0.16	-0.02	**0.67**	-0.02
Backward movement	0.11	0.03	-0.06	**0.45**	0.11
FRT ROM left	0.09	0.29	0.04	0.03	**0.67**
FRT ROM right	0.01	0.02	-0.11	-0.05	**0.78**
CCFT endurance	-0.01	0.11	0.24	0.30	**0.45**

Table 3: clinical pattern of subgroups is shown with respect to the cervical and masticatory systems.

Legend table 3: Arrows indicate effects according to effect sizes. One arrow is a small effect, two arrows a medium effect and three arrows a large effect.

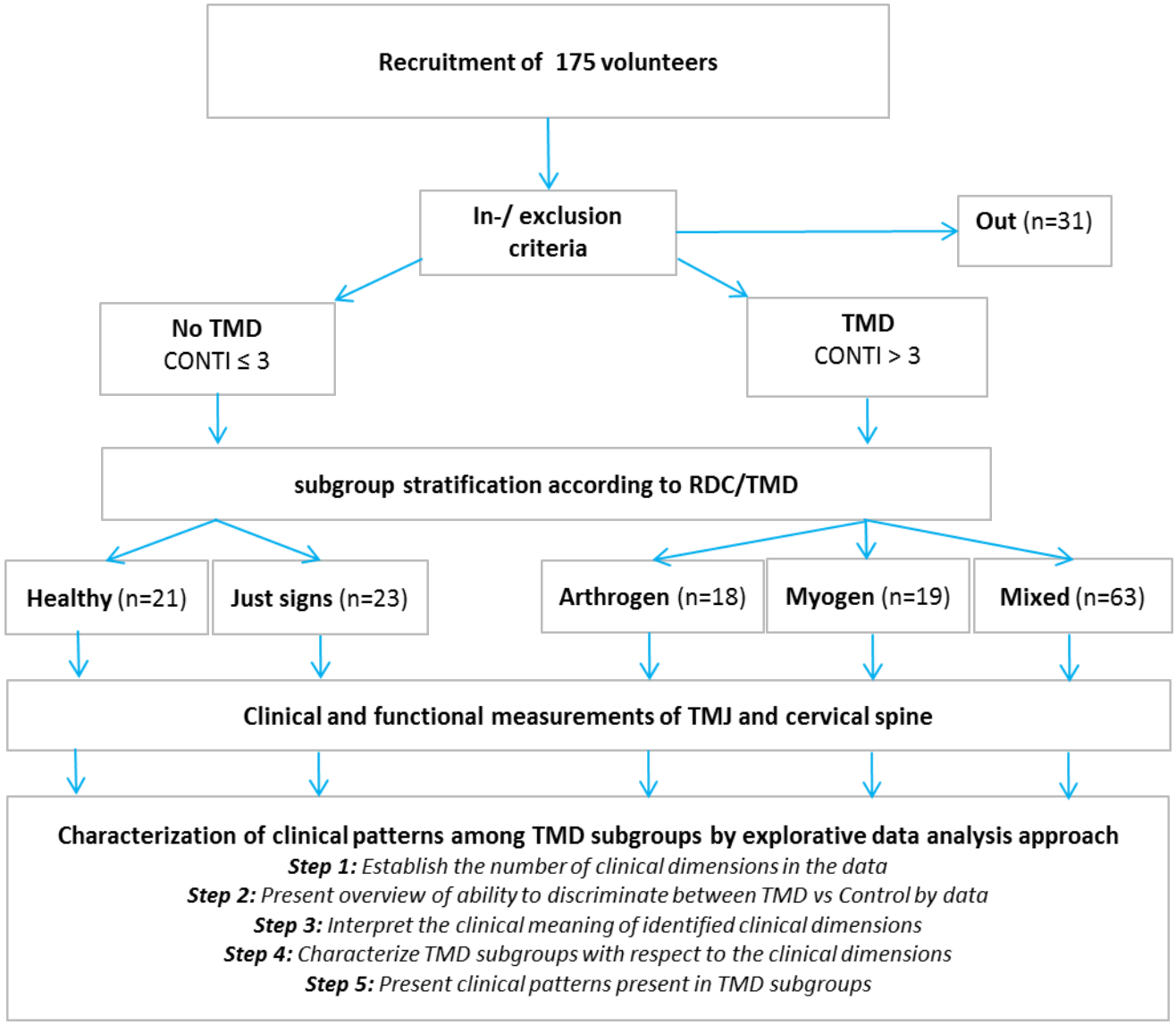
	mechanosensitivity	Cervical ROM	Cervical and masticatory dysfunction	Jaw movement	Upper cervical ROM/endurance

Mixed	↓↓↓	↓↓	↓↓↓	↓↓	-
Myogen	↓	↓	↓↓↓	↓↓	-
Arthogen	-	-	↓↓↓	↓↓	-
Just signs	-	-	-	↓↓	-

660

661

662 Title figure 1: work flow diagram



663 Title figure 2: Scores of all individuals on each of the five extracted factors representing clinical

664 dimensions

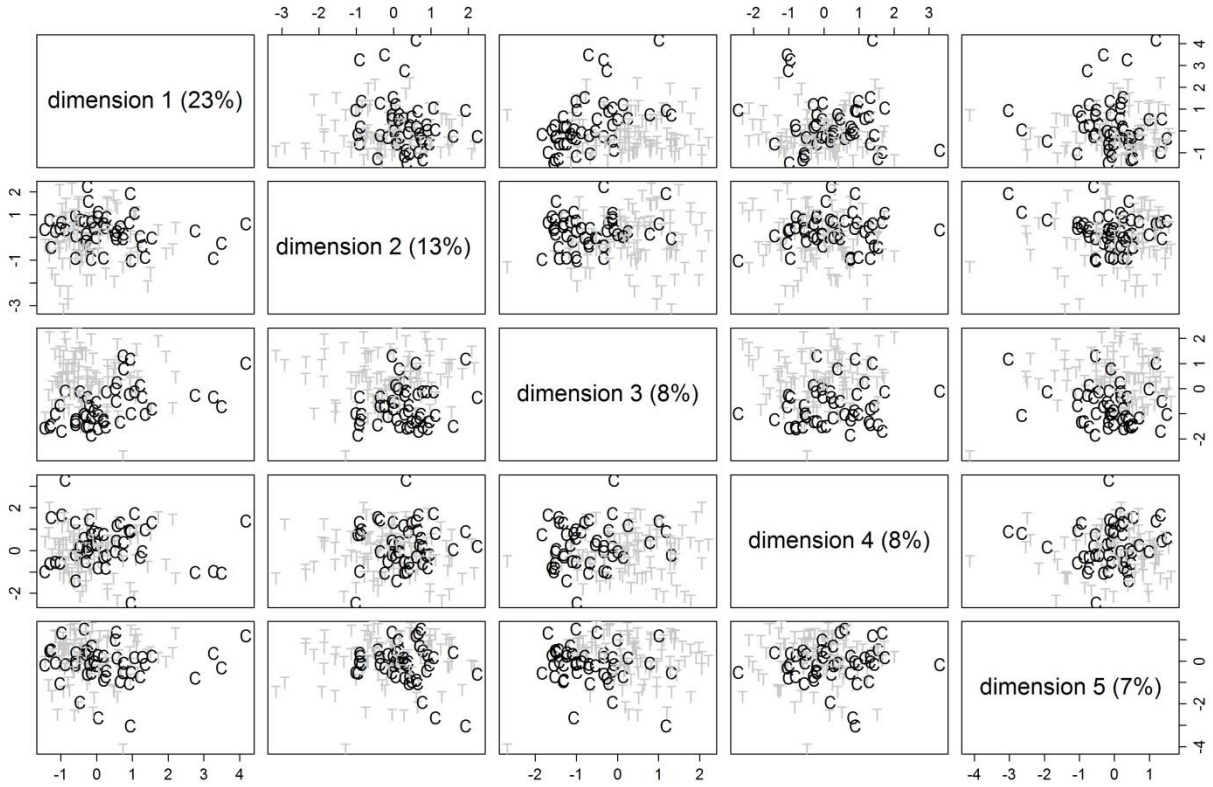
665 Legend figure 2: Black Cs represent the control group including the control group with symptoms of

666 TMD ("Just signs"). Grey Ts represent the TMD group including the "Arthrogen","Myogen" and "Mixed"

667 subgroup. Each plot shows scores of two dimension. E.g. the very left top plot depicts scores of

668 dimension 1 on x-axis and scores of dimension 2 on y-axis Separation of dots with respect to group

669 membership indicate distinct patterns.



Title figure 3: Standardized mean differences of clinical dimensions between subgroups of TMD

Legend figure 3: Differences (±95% Confidence Intervals) are shown between each of the subgroups to control group with respect to all clinical dimensions calculated by linear regression analysis. Factors representing a summary variable of each clinical dimension and single variables contributing to respective dimension are depicted. Results are to be interpreted as effect sizes (beta). Model is adjusted for age and gender where necessary.

Dimension: Mechanosensitivity
Dimension: cervical ROM
Dimension: cervical/masticatory dysfunction and pain
Dimension: jaw movement
Dimension: ROM and endurance upp. cervical spine
TMD subgroup affected
controls affected
summary variable
MS_Temp
MS_Mass
MS_Trap
MS_Obliq
cerv.signs
Flex
Ext
Lateroflex
Rotation
NDI
CONTI
Pain FRT
Pain acute
Mouth open
Lateral shift
Fwd move
Bwd move
endur CCFT
FlexRot
mixed vs control
myogen vs control
arthrogen vs control
just signs vs control
SMD (95% CI)
-2
-1
0
1

678