Patient Concerns and Beliefs Related to Audible Popping Sound and the Effectiveness of Manipulation: Findings From an Online Survey

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Abstract

Objective: The purpose of this study was to assess whether beliefs about the origin of the popping sound and the effects of thrust manipulation (TM) were in agreement with current scientific evidence and whether a practitioner's explanation could influence patient beliefs of theoretical mechanisms.

Methods: A cross-sectional online survey was conducted in Italy from January 7, 2019 to April 20, 2019. The questionnaire was sent to 900 Italian adults through online recruitment, including people with and without a history of manipulation, such as given by physiotherapists, chiropractors, osteopaths, and manual medicine physicians to manage musculoskeletal disorders. The questionnaire consisted of 11 multiple-choice questions and could be completed within 15 weeks. The Likert scale was used to investigate participants' attitudes. Sex and previous experience of TM variables were evaluated using a Student's *t*-test; a 1-way F analysis of variance test was performed to evaluate age, educational qualification, and the professional who performed the TM.

Results: We retrieved 478 questionnaires, including 175 participants with no TM history and 303 with TM history. There were 31% of participants (n = 94) with a history of TM who reported they did not receive explanations regarding manipulation. The participants' beliefs mostly disagreed with the current hypotheses provided by the scientific literature on the theoretical mechanisms of popping sound (tribonucleation and cavitation). There were 9.9% (n = 30) of participants who answered "realignment of bone positional fault" to explain the mechanism behind TM. There was a high degree of agreement with the belief that the popping sound should be present for a successful TM (respectively, 2.8 standard deviation [SD; 1.2] and 2.6 SD [1.2] for TM+ and TM− participants). No statistically significant differences were found between participants with and without a history of TM.

Conclusion: The participants in this study reported a belief that popping was related to effectiveness of TM. A high percentage of this sample had beliefs about TM mechanisms for the audible popping sound that were inconsistent with current literature. Beliefs were similar between groups, suggesting that instructions given by TM practitioners did not seem to be an influence on these patients' beliefs. (J Manipulative Physiol Ther 2022;00;1-9)

Key Indexing Terms: *Public Opinion; Manipulation, Spinal; Physical Therapy Modalities*

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Introduction

High-velocity, low-amplitude thrust manipulation consists of applying a rapid impulse (ie, thrust) accompanied by an audible pop sound (ie, popping sound).[1] Thrust manipulation (TM) is commonly used by physiotherapists, chiropractors, osteopaths, and manual medicine physicians to manage musculoskeletal disorders[2,3] and may be recommended as first-line treatment included in a multimodal program of care.[4-8]

The exact origin of the popping sound is still unknown and under debate. The understanding of this phenomenon is eclipsed by different theoretical constructs raised between multiple professions with overlapping scopes of practice leading to anecdotal beliefs by both practitioners and patients.[9,10]

The first known study[11] to attempt to empirically observe the origins of a popping sound was in 1947. The proposed theory was that a rapid separation between joint surfaces could be responsible for the popping sound.[11] Later, in 1971,[12] this explanation was refuted with the assumption that the subsequent collapse of the vapor cavities released from the solution gives rise to the popping sound,[12] supporting the cavitation phenomenon theory related to the popping sound genesis.[13] In 2015, 10 metacarpophalangeal joints were studied using real-time magnetic resonance imaging.[14] The proposed theory[14] was that the "tribonucleation" phenomenon could be responsible for the popping sound; this physical process applied to TM seems to be characterized by a rapid separation of the joint surfaces with subsequent gas cavity formation, as observed in 1947.[11,14] An observation in 2018[15] using a mathematical model found that only a partial collapse of the bubble was needed to replicate the audible popping sound,[15] allowing the persistence of bubbles after the audible sound, as reported previously.[14] However, the phenomena of tribonucleation and cavitation alone do not explain all possible sounds from a TM. More recently, other authors[3,16,17] analyzed sound wave signals processed by a time-frequency analysis observing that the sound was composed of single and multiple energy releases and frequencies, suggesting multiple mechanisms underlying the popping sound phenomenon.[3,16,17]

The audible popping sound is hypothesized to be the main characteristic of an effective TM.[2,18-24] It is also hypothesized that the absence of a popping sound during TM potentially increases the patient's perception of an ineffective intervention.[25-27] The few systematic reviews that have analyzed the topic found no differences between TM and sham TM treatments (ie, a hands-on technique without thrust and popping sound).[4,28] However, these results should be analyzed cautiously, as the studies had a high risk of bias (ie, sham manipulation often simulates a mobilization; sham manipulations often performed with a mechanical instrument). For these reasons, the clinical relevance of the popping sound is criticized by some research groups,[29-33] and its mechanism is still uncertain.

In a recent survey,[34] clinician and patient beliefs, perceptions, and practices regarding benign adverse events after TM and the strategies to control them were investigated.[34] A discrepancy in beliefs and perceptions between clinicians and patients was observed, mainly owing to a lack of communication leading to a potential reduction of the effectiveness of the treatment.[34] Current scientific evidence on the origin of the popping sound may also be misaligned with patient beliefs.[35,36] This inconsistency between patient beliefs for understanding the popping sound after TM and the explanations currently provided by scientific evidence can potentially alter patient-reported outcome changes.[35]

To the best of our knowledge, only 2 previous studies qualitatively evaluated general populations' beliefs about the popping sound through interviews.[35,36] However, there is still the need for more detailed information about health care professionals' and patients' beliefs and the subsequent clinical relevance of the popping sound. Therefore, this study aimed to investigate a sample of the Italian population about their beliefs on the popping sound and to assess whether beliefs about the origin of the popping sound and the effects of TM were in agreement with current scientific evidence and if a practitioner's explanation could influence patient beliefs about theoretical mechanisms.

Methods

We developed an online cross-sectional survey using the online platform "Google Forms" (Google LLC, Mountain View, California). The study was designed following the Checklist for Reporting Results of Internet Surveys (CHERRIES)[37] and STROBE guidelines.[38]

Setting and Recruitment

Our purpose was to obtain a comparable sample of the Italian population. The sample that we tried to recruit had to be represented by participants who had experience of TM (TM+) to get an idea of how health professionals provide explanations to the patient or how they manage to elaborate on already present beliefs. Furthermore, some participants in our sample had no experience of TM (TM−). We distributed the survey by off-line recruitment, sending 900 invitations through questionnaire link via WhatsApp or e-mail (both of them are items describing off-line recruitment), using personal contacts of 4 authors (M.B., A.V., M.P., F.M.). The contacts of the personal directories of the authors were reported on an *Excel* sheet, associating a number with each contact. The total number of contacts was 1340. Nine hundred contacts out of 1340 possible were selected through an online random number

generator. One of the authors who had not helped provide the contacts (G.R.) carried out the selection process. The duration of recruiting and completing the questionnaire was 15 weeks, from January 7, 2019, to April 20, 2019. After that date, the possibility of completing the questionnaire was no longer possible.

The questionnaire was written in Italian (see supplemental file original language−Italian) and was translated into English for dissemination purposes only (see supplemental file English version). It was introduced by a short read of the background and aim of the survey; the time completion ranged from 5 to 10 minutes to optimize response rates in online questionnaires.[39] The recruitment was voluntary and anonymous; no compensation was offered. Participants were asked to provide their consent before starting the compilation of the questionnaire. The participants had the opportunity to return to the previous question using the "Back" button at any time. All questions were presented in the same order, and full completion was mandatory.

Sample Size

The sample size was calculated according to Demoulin et al,[35] who included 100 individuals to examine beliefs about cracking sounds heard during TM. Of these 100 individuals, 60 had no history of TM, divided into 40 asymptomatic, with or without a history of spinal pain and 20 with aspecific spinal pain. The remaining 40 individuals had experienced TM; 20 were asymptomatic, and 20 experienced spinal pain. Five of 60 healthy participants of the group without a history of TM (8.3%) and 4/40 participants of the group with a history of TM (10%) believed the popping sound was produced by the presence of gas bubbles within the joint (difference between groups = 1.7%). We hypothesized that the treatment with TM has the potential to reduce the percentage of disagreement by at least 1.7% compared with participants who have no history of TM. Starting from these data, we had to identify at least 254 participants (152 without a history of TM and 102 with a history of TM) to guarantee a statistical power of 85% and an α error of 5%. To calculate the sample size, we used the 1-tailed z-test/G-Power software (version 3.1.9.2). Assuming a response rate between 40% and 60%, we sent 900 questionnaires to obtain a number of answers between 360 and 540.[40-42]

Study Protocol and Development of the Questionnaire

Five Italian expert musculoskeletal specialized physiotherapists, with an Orthopedic Manipulative Physical Therapist qualification, and members of the faculty of the master degree on the rehabilitation of musculoskeletal disorders of the University of Genova (Italy), developed the questionnaire. The survey was reviewed by 15 physiotherapists experienced in TM. Five of the authors (with Orthopedic Manipulative Physical Therapist qualification) piloted independently and then critically edited the questionnaire to increase face validity focusing on the logical and contents' accuracy and questions' understanding. Next, a first-survey version was administered to a sample of 30 participants selected from family members and patients, contacted by phone, to evaluate possible misunderstandings, language difficulties, and formulation complexity. The piloting process and comparison with a previous survey strengthened the content validity.[35]

The final version of the survey (see supplemental file) was composed of 11 multiple-choice questions divided into 2 sections. Before beginning the questionnaire, an explanatory video of a lumbar TM was shown to allow participants without any experience with TM to understand the technique better and listen to the popping sound. In the first section, following the declaration of the legal age and informed consent, we asked participants to enter sociodemographic data with an open question for the age and 2 closed questions for sex and educational qualification. The second section investigated beliefs regarding the popping sound and the effects of TM using 8 closed questions (7 out of 8 with a 6-item Likert scale). The Likert scale was used to investigate participants' attitudes; the questionnaire's internal consistency was assessed calculating Cronbach's Alpha coefficient, and only items in accordance with the Likert scale options were considered quantitative variables. Questionnaire satisfaction was 0.788 (see supplemental Table A).

Statistical Analysis

Quantitative variables were described as mean ± standard deviation (SD), which indicate the degrees of disagreement between the measured variables: the score ranges from 1 (totally agree) to 6 (totally disagree). The results section reports the average score and SD of the disagreement between groups. The qualitative variables (question number 5 only) were described as the percentage of answers.

The following variables were analyzed from the questionnaire: sex (male/female), age, educational qualifications, TM history, and the professional who performed the TM. The respondent's sex and TM history variables were analyzed using a Student's *t*-test for independent samples; a 1-way F analysis of variance test was applied to evaluate age, educational qualifications, and professionals who performed the TM.

Ethics

This study was approved by the Human Subjects Committee of the Department of Physical Therapy,

Occupational Therapy, Rehabilitation and Physical Medicine, Universidad Rey Juan Carlos of Madrid with approval URJC DPTO 55-2020. The authors followed the principles outlined in the Declaration of Helsinki for this study.[43]

Results

Participants' Characteristics

Of the 900 invitations, we collected 478 completed questionnaires, with a response rate of 53.11%. No data were detected regarding participants who did not answer the questionnaire. More than half (63.4%) of the participants (n = 303) had previously experienced a TM treatment, 55.78% of whom (n = 169) had been treated by a physiotherapist. Table 1 summarizes the participant demographics and baseline characteristics.

Table 1. *Participants' Characteristics*

Demographic Data	Values (%)
History of HVLAT	
No HVLAT received (TM−)	175 (36.6)
HVLAT received (TM+)	303 (63.4)
Sex	
Male	205 (42.9)
Female	273 (57.1)
Age	
18-39 y	347 (72.6)
40-59 y	98 (20.5)
60-79 y	33 (6.9)
Educational qualifications	
Middle school	39 (8,2)
High school	218 (45.6)
University degree	216 (45.2)
Doctor of Philosophy (PhD)	5 (1)
Professional who performed spinal manipulation	
No HVLAT received	175 (36.6)
Received from a physician	22 (4.6)
Received from a physiotherapist	169 (35.4)
Received from other professional	112 (23.4)

Data are expressed as a percentage of responses.
HVLAT, high-velocity low-amplitude thrust; *TM,* thrust manipulation.

Qualitative Variables

Among the participants, 31% (n = 94) experienced TM but reported they did not receive an explanation before the technique delivery from the practitioner (question 5: When you were manipulated, did you receive explanations about the effect the technique would have on you or your symptoms?). Of those reporting they received an explanation, 18.2% (n = 55) reported that the explanation was "symptoms' reduction"; 10.5% (n = 32) reported the explanation as "recover of a normal movement pattern"; 9.9% (n = 30) reported "realignment of bone positional fault"; 6.3% reported "joint disc repositioning" as their explanation (Fig 1 and Table 2).

Continuous Quantitative Variables

The continuous quantitative variables (all questions excluding number 5) were elaborated with a 6-item Likert scale. The values calculated for each question indicate the degree of agreement or disagreement between groups, and the standard deviation (SD) measurement expresses the average value. See supplemental Tables B through E, which summarize questions with a statistically significant disagreement and analyze sex, age, educational level, and the professional who performed the TM. Nonstatistically significant data for variable TM+ and TM− are available in supplemental Table F.

Participants mostly did not identify tribonucleation (4.3 [SD 1.7] and 4.5 [SD 1.6] for TM+ and TM− participants, respectively) nor cavitation (3.8 [SD 1.9] and 3.9 [SD 1.8] for TM+ and TM− participants, respectively) as primary mechanisms of the popping sound (see supplemental Tables G and H). Instead, they attributed the cause to the release of a stuck vertebral segment (2.9 [SD 1.6] and 3.1 [SD 1.5] for TM+ and TM− participants, respectively) or to the realignment of a vertebral positional fault (3.4 [SD 1.7] and 3.4 [SD 1.6] for TM+ and TM− participants,

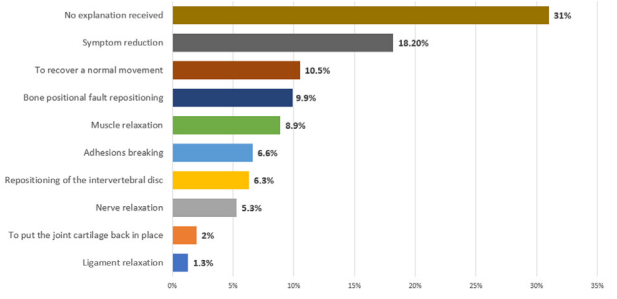

Fig 1. *Summary graph of participants' answers with thrust manipulation history.*

Table 2. *Responses to "When You Were Manipulated, Did You Receive Explanations About the Effect the Technique Would Have on You or Your Symptoms?" and the Professional Reported to Have Provided the High-Velocity Low-Amplitude Thrust (HVLAT)*

Answer	Participants with HVLAT History	Physiotherapist	Other Professional	Physician
Ligament relaxation	1.3%	1.2%	1.8%	/
To put the joint cartilage back in place	2%	2.4%	1.8%	/
Nerve relaxation	5.3%	4.7%	7.1%	/
Joint disk repositioning	6.3%	5.9%	6.3%	9.1%
Adhesions breaking	6.6%	4.1%	8.8%	13.6%
Muscle relaxation	8.9%	12.4%	4.5%	4.6%
Realignment of bone positional fault	9.9%	12.4%	4.5%	18.2%
Recover of a normal movement pattern	10.5%	8.3%	14.3%	18.2%
Symptom reduction	18.2%	17.8%	17.9%	22.7%
No explanation received	31%	30.8%	33%	22.7%

Data are expressed as a percentage of responses.

respectively; see supplemental Tables 1 and J). Interestingly, these findings were not observed on those participants with a PhD (m = 4.4; SD = 1.5) and those manipulated by a medical doctor (m = 4.0; SD = 1.8). Finally, we found a high degree of agreement with the belief that the popping sound should be present for a successful TM (2.8 [SD 1.2] and 2.6 [SD 1.2] for TM+ and TM− participants, respectively).

Discussion

To the best of our knowledge, only 2 previous studies[35,36] have investigated the general population's beliefs regarding the popping sound; however, these 2 studies have a main limitation of not being generalizable because of the small sample size.[35,36] Our purpose was to obtain information from a sample of Italian population regarding beliefs about audible popping sound and the effectiveness of manipulation. Our survey results show no statistically significant differences between participants with or without a history of TM, which suggests that general population beliefs do not change after the experience of receiving TM treatment. Our survey also found a communication issue: 31% of participants (n = 94) with a history of TM did not recall receiving explanations on the mechanisms and effects of TM from health care practitioners who were delivering TM. On the basis of our findings, patients were not given information consistent with the current literature on theoretical mechanisms of TM when the explanations were offered by providers.[4,5,24,44,45]

Regarding beliefs of the origin of the popping sound, patients reported an understanding of the mechanisms that is not aligned with current literature.[14,15] The most agreed-on explanation among participants was the release of a stuck vertebral segment (supplemental Table 1). In previous research,[35] only 9% of participants (5 of 60 participants without a history of TM and 4 of 40 among those with a history of TM) believed the popping sound originated from the formation and subsequent collapse of gas bubbles in the joint. The low number of participants could be explained by the rather recent hypotheses of the mechanism underlying the production of the popping sound (ie, cavitation and tribonucleation)[14,15] that may need more time to spread to the general population.

Among participants who previously experienced TM, excluding those who did not receive information (n = 94; 31%), the explanations provided on TM effectiveness aligned with current literature.[4,5,24,44] However, a few participants (n = 30; 9.9%) reported they believed that the effectiveness of TM depended on "realignment of bone positional fault." Our results agree with Miller and Poggetti,[36] who reported that 6 out of 8 participants believed that "If it cracks, you know it has moved." On the other hand, Demoulin et al[35] found that 49% of participants (50% of participants with a history of TM; 48.3% of participants without a history of TM) believe that the popping sound was due to vertebral segments repositioning. Compared with Miller and Poggetti's results,[36] Demoulin's results[35] may be more reliable because of the larger sample size (respectively, 100 participants and 8 participants). Moreover, although both authors used opportunistic recruitment, Miller and Poggeti's[36] participants were all

from the same clinic (Anglo European College of Chiropractic).

Educating the patient from a biopsychosocial perspective could have important repercussions on the patient's perception of pain and factors that could promote chronicity of musculoskeletal disorders, such as functional impairments and kinesiophobia.[34,46] It has been reported that some health professionals maintain an overly biomedical approach to patients who have acute or chronic low back pain and that this model can convey to the patient the belief that their back is fragile, leading to perpetuated limitations in activity, social participation, and unfavorable outcomes.[47,48] For these reasons, it is important to provide explanations of the most likely effects of TM, excluding options that are not currently supported by scientific literature (ie, realignment of bone positional fault) or to provide knowledge about the most likely mechanism of popping sound production.[14,15,35,48]

Inaccurate beliefs may be among the most important risk factors for the evolution of musculoskeletal disorders toward chronicity, being able to contribute to the limitation of self-efficacy of symptoms.[48] Patients may believe that symptom relief and healing are primarily, if not exclusively, dependent on the therapist, in addition to not perceiving that they are the protagonist of their treatment process.[48]

Although the role of the popping sound as a criterion for a valid TM is still debated,[30,49-51] we found a high degree of agreement with the belief that the popping sound should be present for a successful TM (see supplemental Table K). Similarly, the first research on popping sound beliefs previously reported that 6 out of 8 participants believe the popping is necessary,[36] while Demoulin [35] found that 60% of participants (62.5% with TM previous experience) did not believe the popping sound was required. Notably, differences in results can be explained by the different nationalities of the participants (Belgium and United Kingdom) and the presence of different backgrounds of the clinicians (chiropractor vs physiotherapist). There was no evidence that clinicians can change patients' beliefs regarding their complaints,[47] but they seem to influence their beliefs by reflecting the health care professionals' background and knowledge.[52]

The notion of whether the popping sound needs to be heard during a TM to be effective arises mainly from a single study. That is, no outcomes changes were observed (range of motion, pain, and disability) after a sacroiliac TM, with or without popping sounds.[29] However, these results remain questionable mainly from the study design: TM was repeated once the popping sound was not perceived, suggesting its expectation by the physical therapist that could in turn influence the patient's belief; in addition, the nocebo effect may be elicited when the popping sound patient's expectation is not respected.[35] It has been suggested that TM relies on 3 main effects: a contextual effect (ie, placebo) that is intrinsic to each treatment maneuvers given by those gestures that the practitioner implements during the manipulative delivery representing the "ritual" of the technique[44]; a biomechanical effect; and a neurophysiological effect.[30,44,53] Also, one may expect a placebo/nocebo effect following the manipulative delivery if on the patient's expectation is respected or not.

Patients' expectations on the popping sound during TM may be important for satisfaction and a "freeing sensation"[36] and seem to be related to patient-reported outcomes[54]; however, certain hypoalgesia mechanisms (ie, mediated by c fibers) after TM may occur regardless of their expectations.[54] Thus, expectation and placebo effects are active and important mechanisms of TM and must be considered as an essential component of treatment effect by clinicians.[55] Moreover, with the aim to reduce the nocebo effect response related to popping sound absence after TM, clinicians should also be aware of how they are educating and preparing the patients before the technique delivery.[56,57] After all expectations, psychological aspects and contextual cues have been shown to play a role in modulating patient's response to treatment of any nature.[58,59]

Recommendations

According to the results of our study, practitioners who perform TM should pay attention to patients' beliefs and clearly explain the aim and effectiveness of TM using current theoretical models. The limited number of studies underlines the need for further research on the topic, with the final goal to improve knowledge on beliefs and reduce the communication gap between both patients and clinicians, increasing the effectiveness of manipulative treatment.

Strengths and Limitations

Our survey included 478 participants and reached the required sample size calculation, resulting then, the study with the higher number of participants recruited, compared with previous studies on this topic.[35,36] However, a bigger and more homogeneous sample size would be required to represent the general population fully (ie, participants with PhDs or manipulated by physicians). Furthermore, we could not control whether participants had sought information from external sources (ie, Internet/specialized people) before answering the survey questions. The participants' selection method was potentially subject to selection bias and therefore may have influenced the results. Moreover, we did not conduct a qualitative interview that would have helped clarify the participants' questions and doubts to investigate the tendency of neutral values in Likert scales. Finally, as we included only Italian participants, the generalizability of findings may be limited, thus limiting our results to this country.

Conclusion

The participants in this study report a belief that popping is related to effectiveness of TM. A high percentage of the

patients surveyed in our study reported that their practitioners had not informed them about the effects and mechanisms of TM. Regardless of respondents having or not having previously experienced TM, their beliefs about TM were inconsistent with current literature on theoretical mechanisms of the popping sound. There were no differences between groups; thus, explanations provided by TM practitioners did not seem to influence the patients' beliefs.

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No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): M.B., A.V., F.Mo., F.Ma.
Design (planned the methods to generate the results): M.B., A.V., F.Mo., G.R., F.Ma., Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): F.Ma., F.M.O., C.F.dP., J.D., M.T.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.B., A.V., F.Ma.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): M.B., A.V., F.Ma.
Literature search (performed the literature search): M.B., A.V., F.Mo., G.R., M.P., J.D., C.F.dP., M.T., F.Ma.
Writing (responsible for writing a substantive part of the manuscript): M.B., A.V., F.Mo., G.R., M.P., J.D., C.F.dP., M.T., F.Ma.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): F.Ma., F.Mo., C.F.dP., J.D., M.T.

Practical Applications

- The participants in this study reported a belief that popping was related to effectiveness of TM.
- A high percentage of this sample had beliefs about TM mechanisms for the audible popping sound that were inconsistent with current literature.
- Beliefs were similar between groups, suggesting that instructions given by TM practitioners did not seem to be an influence on these patients' beliefs.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jmpt.2022.03.021.

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