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Risk of Headache, Temporomandibular Dysfunction and Local Sensitization in Male Professional Boxers: A Case-Control Study

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The study was performed at an University-based physical therapy research clinic.

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No reprints are avaible for this study.

The study protocol was approved by the Ethical and Research Committee of the University of Sevilla, Spain.

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Abstract

Objective: To evaluate the differences in the incidence of headache, trigeminal nerve mechanosensitivity, and temporomandibular functionality, in professional male boxers (exposed to repetitive cranio-facial trauma) who were actively training and without severe previous injuries, compared to handball players.

Study Design: Case-control study.

Setting: University-based physical therapy research clinic.

Participants: Eighteen boxers as the cases group and twenty handball players as the comparison group (age, ± 2 years, and sex matched), were included (23 ± 4.61 years). All participants completed the assessment protocol.

Interventions: Not applicable.

Main Outcome Measures: Measurements were taken of the headache impact (Headache Impact Test-6) and the pressure pain threshold (PPT) over the trigeminal nerve sensory branches, the masseter and tibialis anterior muscles. Secondary outcome measure included the temporomandibular function (Helkimo Clinic index).

Results: The boxers showed slight mandibular function impairment, local muscular and neural sensitization and a higher impact from headaches compared to the handball players. The between-group comparison found significant differences in all outcome measures ($p<.05$), except in the tibialis anterior muscle PPT on the dominant ($p=.958$) and the non-dominant sides ($p=.453$).

Conclusion: Professional male boxers seem to suffer a greater headache impact and local sensitization of the craniomandibular region when compared to

professional handball players. It cannot be determined if these findings are transient, as a result of the training activity, or more permanent.

Key Words Boxing; Case-control study; Headache; Sensitization; Sport.

List of abbreviations

TMD temporomandibular disorders

MTP myofascial trigger points

TMJ temporomandibular joint

PPT pressure pain threshold

TA tibialis anterior muscle

HIT-6 headache impact test-6

V1 supraorbital nerve

V2 infraorbital nerve

V3 mental nerve

HCI helkimo clinic index

BMI body mass index

Boxing is one of the 'contact sports' that generates more controversy.[1] Up to about 34% of professional fights lead to later injury.[2,3] The most common problems occur at the cranio-facial, cervical and hands level.[1] Craniomandibular trauma in boxers can cause concussion, jaw fractures, facial lacerations and dental contusion.[4] Head and face injuries account for about 20% of medical consultations in this sport.[5] The nervous system may also suffer mechanical stress due to the repeated blows.[6] At least 17% of boxers develop chronic traumatic encephalopathy after repetitive concussion, [7] with headache being one of the most common symptoms.[8] Even though headache usually appears right after the injury, it seems to be long lasting.[9]

Increased pain experience among high-level athletes has been correlated to reduced sensitivity for pain.[10] Competitive sport practice has also been linked to increased endogenous opioid activity and altered hormones, which could result in changes of the neural matrix and nociceptive pathways.[10]

Orofacial pain is present in 96.1% of subjects with temporomandibular disorders (TMD),[11] and it can lead to an alteration of the nociceptive modulation in the Central Nervous System, starting from afferent impulses from the cranio-cervical region.[12] As a consequence, a central sensitisation process may take root, manifesting as muscle tissue tenderness, a decreased mechanosensitive threshold and an extension of the areas of referred pain.[13] For this process to become established, there must be prior peripheral sensitisation, prolonged over time, and induced mainly by the release of algogenic substances that irritate the peripheral nerve endings, particularly in muscles.[14] Peripheral sensitisation has been described as the local sensation of hurt and pain resulting from an enhanced responsiveness of nociceptive pathways to peripheral natural stimuli.[15,16] Therefore, it is a nociceptive pain that reflects the perception of noxious stimuli.[17] It seems to induce changes in the posterior horn of the spinal cord associated with the afferent nerve fibers of the affected tissues,[16] and to contribute to central sensitisation.[17] The presence of myofascial trigger points (MTP) can generate nociceptive impulses which, when sustained over time, may lead to a state of central sensitisation.[12] In addition, myofascial pain has been purported to play a key role in the establishment of tension-type headaches.[18]

The purpose of the study was to observe the differences between sports-people exposed to repeated cranio-facial trauma (boxers) versus high-level sportsmen (handball players) not exposed to such continual trauma, with regards to neural and muscular mechanosensitivity at a cranio-cervical level, the impact of headache, and the temporomandibular function.

Methods

Study Design

An observational, and blinded case-control study was carried out. All the participants were divided into two groups taking into account the exposure (boxers) or non-exposure (handball players) to a risk factor (cranio-facial trauma).

Sample Size

Sample size calculation was made considering a 20% difference on mechanosensitivity in the between-groups comparison,[19] an estimated interindividual coefficient of variation for pain threshold measures of 20%, an alpha value of 0.05 and a 80% power (Tamaño de la Muestra 1.1®).[a] Sixteen subjects per group were necessary to complete the study. A loss to follow-up rate of 10% was taking into account.

Study Population

Based on a non-probability convenience sample, from April to August 2012, 18 male elite boxers, and 20 handball players (age, within ± 2 years, and sex matched) [20] as the comparison group, were selected (figure 1). To minimize sampling bias, all eligible participants were drawn from the population of the same source (a high-performance sports centre), in the same sex- and age-groups, and were included in the final analysis.

Sixteen of the eighteen boxers were part of the national team and all were awarded scholarships by the national sports council. The boxers had competed previously in European and world championships, and some of them in the Olympic games. The active training of the boxers consisted of physical training (running, skipping, and gym) and training in skills. The latter was divided in different routines of "shadow-boxing", and practices with the punch bag and the punch ball to improve speed and accuracy. Training with sparring was practiced with heavier and better padded boxing gloves to soften the punches, and it was only performed occasionally for those who were in the four weeks prior to competition. At the time of study, the handball players were playing in honour division B, and some of them had previously participated in international championships.

The inclusion criteria were: (a) active sports male; (b) aged between 18-35 years; (c) receiving regulated training at least 5 days/week; (d) no previous fight for at least 45 days prior to the study for the boxers.[21] The exclusion criteria were: (a) a medical record of fractures and/or surgery at any vertebral, cranial vault, facial bones or temporomandibular joint (TMJ) level; (b) central and/or peripheral degenerative diseases; (c) a history of suffering from active migraine, based on a positive response to any of the following questions ''Have you suffered from migraine over the year before data collection?" and "Do you have a medical diagnosis of migraine from a consulting physician, e. g., a neurologist?";[22,23] (d) a previous history of osteitis, rheumatic diseases or tumours; (e) current use of any medication (e.g., anti-inflammatories, analgesics) which might interfere with the results; and (f) subjects undergoing orthodontic treatment.[24]

The study protocol complied with the ethical precepts of research involving human subjects. It was designed and conducted according to the Helsinki Declaration and was approved by the Institutional Review Board.

Data Collection Protocol

Upon confirming that the participant fulfilled the inclusion/exclusion criteria, the subjects provided written informed consent. Then, the individuals received the evaluation protocol together in a single session that lasted around fourty-five minutes. Boxers were asked about their fighting history (age when boxing started as a competitive sport).[21] The measurements were performed by an evaluator previously trained in handling the measurement tools, and with 10 years of clinical experience. The evaluator was blinded to the aims of the study and to the case/control status of the participants.

Outcome Measures

Pressure Pain Threshold (PPT)

The PPT is the minimum force needed to induce pain or discomfort.[25] The measurements were made using a digital algometer,[b] model FPX 25, with a contact probe size of 1cm^2. Pressure was applied with a depth of 5N/cm^2/sec. The PPT was measured on both sides in: (a) emerging trigeminal nerve sensory branches. The supraorbital nerve (V1) was found in the superior orbital margin in the frontal bone.[26] The infraorbital nerve (V2) was found below the inferior orbital rim and in line with the pupil.[27] The mental branch (V3) was located below the corner of the mouth and slightly medial;[27] (b) masseter muscle. The reference point was located 1 cm cranial and 2 cm anterior to the mandibular angle considering the minimum criteria outlined for MTP (presence of a palpable taut band with a tender spot within it, referred pain pattern, and local twitch response provoked by palpation of the MTP) [28]; and (c) tibialis anterior muscle (TA). The TA was located halfway between the most superior attachment to the tibia and its tendon in the upper one third of the muscle belly. [29] The TA has been previously used as a remote location on the study of central or peripheral sensitisation in chronic-whiplash associated disorders,[29] myofascial TMD,[30] shoulder impingement syndrome,[31] and tension-type headache.[32]

Three measurements were performed with a 30 seconds interval, and the mean was taken as the reference value.[33] Pressure algometry has proven to be valid and has shown a high inter-examiner reliability, ICC = 0.91 (95% CI 0.82-0.97).[34] The standard error of measurement range from 5.06 N/cm^2 to 6.27 N/cm^2.[34]

Headache Impact

The headache impact test 6 (HIT-6) is a self-administered questionnaire that evaluates the general and the previous four-weeks headache impact in the functional capacity of the individual at a work and social level.[35] A final score below 50 points implies that the headache is not functionally disabling. Above this score, the impact is classified as mild (50-55), moderate (56-59) and severe (> 59).[35] In adolescent athletes, the HIT-6 has observed good internal consistency (α = .90), and test-retest reliability (r = .72).[36]

Mandibular functionality

The Helkimo clinic index (HCI) analyses the presence of signs and/or symptoms of TMD. This index evaluates mandibular mobility, the presence of joint sounds and/or muscle pain (in the TMJ itself or during its movements) and deviations in the jaw movements.[37] Subjects may present a negative (<5), moderate (5-9 points) or severe (≥ 10 points) dysfunction in the HCI.[37] The HCI has shown a good inter-examiner reliability, ICC between 0.744 and 0.838.[38]

Statistical Analysis

The data were processed using the PASW advanced statistics 18.0 programme.[c] The results are expressed as mean, with the corresponding standard deviation (SD) and/or 95% confidence intervals (95% CI). The Shapiro-Wilk test was used to analyse the normality of the variables. All outcome variables followed a normal distribution (p>.05) and were analyzed with parametric tests.The baseline characteristics of the study groups (age and body mass index, BMI) were compared with the Student t test. The frequency distribution of the subjects in regard to the HIT-6 and HCI scores was assessed with the Chi-square test (X^2).

To minimize the risk of type 1 error, the between-groups comparison of the mean differences in the PPT, HIT-6 and HCI was performed using a multivariate analysis of variance (MANOVA test). Post-hoc testing was assessed with Bonferroni correction. Effect sizes (partial eta square) for these comparisons were used considering that a small effect has a value ≥ 0.2 and < 0.5, whereas a moderate effect is considered to be a value ≥ 0.5 and < 0.8, and a large effect must be ≥ 0.8.[39]

Finally, the impact of age and BMI was assessed as possible confounding variables in the outcome measures, by means of contingency tables (2x2) (Chi-square).The statistical analysis was conducted considering significance at a p value < .05.

Results

The baseline characteristics of the sample are displayed in table 1. The BMI found statistical significance in the between-groups comparison (p<.05), although both groups showed values within the average range (18.5 - 24.99 points). Boxers had been fighting for 7.5 ± 2.64 years, whereas handball players had been playing for 9.1 ± 3.43 years.

According to the MANOVA overall analysis, Wilks' Lambda value was 0.228, F-ratio was 6.246 and p-value <.001. Table 2 lists the between-groups mean differences (MANOVA) in the post-hoc comparison of the outcome measures. The boxing group showed an increased mechanosensitivity in all the locations and on both sides, with statistical significance (p<.05), except for the TA on the dominant side (p=.958) and on the non-dominant side (p=.453). Considering the average value of the measurements in both sides (table 2), the effect size was close to moderate for V1 [p<.001; $F_{1,36}$=24.12; R^2=0.40] and V2 [p<.001); $F_{1,36}$=23.55; R^2=0.38], and low for V3 [p=0.015; $F_{1,36}$=9.59; R^2=0.21]. For the masseter muscle, the effect size was also moderate in the dominant [p<.001; $F_{1,36}$=47.90; R^2=0.57] and non-dominant sides [p<0.001; $F_{1,36}$=46.00; R^2=0.56].

Table 3 presents the frequency distribution of the study subjects with regard to the severity of the HIT-6 and HCI results. The HIT-6 values were lower in the handball players, with significant diferences in the between-groups comparison, and a small effect size [p=0.028; $F_{1,36}$=5.28; R^2=0.12]. Although 55.5% (10/18) of the boxers revealed a mild or moderate impact in the HIT-6 (value >50), compared to only 20% (4/20) of the handball players (table 3), the average score in both groups (value below 50) showed that the headache was not functionally disabling in any of them. Similar results were observed from the HCI. The mean value in the boxers (7.44 ± 4.00) indicated a moderate TMD compared to an absence of TMD in the handball players (3.81 ± 2.25) (table 2). The inter-group mean difference was also significant [p=0.008; $F_{1,36}$=8.02; R^2=0.18].

The between-groups comparison using contingency tables showed no statistical significance between age and BMI and the measured variables (p>.05).

Discussion

This study has assessed the differences in headache impact, orofacial mechanosensitivity and TMJ functionality between sportsmen exposed to repetitive craniofacial trauma, as an associated risk factor, and high-level handball players.

With regard to the PPT, the results seem to indicate that professional boxers in training showed increased excitability in the trigeminal nerve sensory branches and in the masseter muscle, but not in a distant location, the TA, when compared to the handball players. The capacity to withstand pain is a key factor in competitive sports, and pain tolerance appears to differ between athletes and non-sports people.[10] Therefore, the comparison group included high-level athletes that were selected from a single sport to homogeneize the sample and increase internal validity. Mechanosensitivity thresholds were similar in a distal muscle, the TA, which would help to assume that both groups were suspected to have similar pain tolerance.

The present findings may suggest a local sensitization in the craniocervical region of the boxers. Local sensitization can increase the presence of pain in chronic injuries in high-level sports people.[40] Whether these differences are only transient as a result of the training activity remains unknown. For a sensitization phenomenon to occur, a maintained nociceptive input is required.[30] Boxing carries risk of facial and head injuries that are self-evident, and the incidence of contact injuries increases in professional boxing,[2] compared to other sports such as American football, wrestling and soccer.[3,4] .

The impact of headache was also higher in the boxers. The use of a self-report headache scale, like the HIT-6, as part of a testing protocol for concussion, appears to help clinicians to identify those with existing headache disorders.[36] A difference ≥ 5 points in the HIT-6 has been reported as clinically meaningful, whereas a 3-point change is considered to be remarkable.[41] According to this, the between-group difference in the present study (4.82 points) could be considered close to clinical relevance. Among the boxers, only 45.5% (8/18) revealed no functionally disabling impact in the HIT-6, compared to 80% (16/20) of the handball players (table 3). Nonetheless, HIT-6 scores in both groups were within the average values for non-functionally disabling headache. Hence, results must be interpreted with caution. Sensitization of the cranial nerves may contribute to the establishment and severity of headache.[26] Trigeminal nerve increased excitability, such as that found in the boxers, has been linked to increased prevalence of migraine,[12] and to chronic-tension or cervicogenic headache.[26] Different headache subgroups have been established when considering the management of headache in sport, including the *"headache arising from mechanisms that occur during exertion",* i.e. headaches resulting from trauma, impact and/or cervical dysfunction.[42] This subgroup could be linked to boxing, although no direct relationship has been found between the severity of the impact and the resulting headache.[42] Changes in the vascular pressure and heart rate may also be related to headache in sport.[42] However, these aspects have not been monitored in this study.

The trigeminal caudal nucleus is responsible for innervating the masticatory muscles.[43] Therefore, the increased mechano-excitability over the masseter muscles in the boxers is consistent with the hypersensitivity recorded in the trigeminal nerve branches in these subjects. A sensory impairment in the trigeminal nerve has been purported to be associated with TMD,[30] and trigeminal neuropathic pain is frequently caused by trauma.[44] A sensitization process (central or peripheral) may also be involved in the development of these disorders.[30] Pain in the muscles of mastication has been found as the most prevalent sign of TMD among young athletes who play basketball.[45] For the HCI, 77.7% of the boxers (14/18) had moderate or severe TMD (table 3), and the mean value in this group was 7.44 ± 4.00, which confirms the presence of signs and symptoms of a moderate disorder. Between 44% and 99% of TMDs are secondary to trauma, which may help to explain our findings.[46] Moreover, the absence of immediate symptoms or injury is common in contact sports that involve direct trauma to the jaw.[45]

Despite the observed differences, all the boxers in the sample used a head protector and a mouth guard, both in sparring training and in actual competition events. The use of foam head guards has shown to be effective in preventing superficial head injuries, although their effect on severe head injuries is unknown.[47] The mouth guard prevents tooth loss and minimises the impact of trauma directly upon the oral cavity,[48] although scientific evidence on its effect in preventing contusions is lacking. Its use is considered a priority in contact sports because it decreases the risk of orofacial injury between 1.6-1.9 times.[49]

Limitations of the study

The prevalence of injury is higher in male boxing than in female boxers.[1] Hence, the study only evaluated male subjects. It would be interesting to assess whether there are gender-related effects in regard to the local sensitization, the headache impact and the TMJ functionality. Future studies should include men and women, and other sports with high risks of cranio-facial impacts and potential for injury, such as rugby, martial arts, and basketball.[50] It also seems necessary to compare the present findings with a control group of non-sports subjects, as in previous studies.[45] Handball players are physically quite different from boxers, which makes blinding difficult. Nevertheless, the evaluator was unaware of the aims of the study and the groups to be tested.

Boxers were included in the study if they had not fought in a competition within 45 days prior to the study. Nonetheless, training habits regarding sparring schedules before data collection were not controlled, which may have influenced the results.[21] It is plausible to state that the present findings may only reflect transient changes because of the ongoing sparring training instead of permanent changes. The results suggest the need to assess boxers later in life to observe the possible impairments and the duration of changes. In addition, those boxers with a severe prior injury were excluded, yet these are the ones most likely to have an orofacial problem.

Conclusion

Male professional boxers who are actively training seem to show a local muscular and neural sensitization in the orofacial region, a higher impact from headache and slight TMD, when compared to high-level handball players. It cannot be determined if these findings are transient, as a result of the training activity, or more permanent.

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Suppliers

a. Pontificia Universidad Javeriana, 40-62, Carrera 7, Bogotá (Colombia), 11001000.

b. Wagner Instruments, 17 Wilmot Ln, Riverside, CT, 06878.

c. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL, 60606.

d.

Figure Legends

Figure 1 Flowchart Diagram of the Study Subjects.

Table 1 Baseline characteristics of the subjects in the study groups*

	Total Sample (N=38)	Boxing Group (n=18)	Control Group (n=20)	p value
Mean Age (yrs)	23 ± 4.61	22 ± 4.06	23 ± 5.04	.299
BMI (kg/m²)	22.71 ± 2.83	20.76 ± 2.27	24.47 ± 2.02	.001

Abbreviations: BMI, Body Mass Index; p-value, statistical significance of the difference between groups.

*Data are reported as mean ± standard deviation

Table 2 Between-groups differences of the headache impact, mandibular function (Helkimo test) and muscular and neural mechanosensitivity*

		Mean value ± SD	Between-group mean differences (95% CI)	p-value
HIT-6	Boxing Group	48.77 ± 5.77	4.82	.028
	Handball Group	43.95 ± 7.02	(0.56 / 9.08)	
PPT-V1 D	Boxing Group	13.94 ± 4.57	- 7.06	<.001
	Handball Group	21.00 ± 4.44	(-10.22 / -3.90)	
PPT-V1 ND	Boxing Group	14.77 ± 4.42	- 7.09	<.001
	Handball Group	21.87 ± 4.82	(-10.32 / -3.86)	
PPT-V2 D	Boxing Group	20.78 ± 6.79	- 13.15	<.001
	Handball Group	33.94 ± 8.06	(-17.12 / -7.14)	
PPT-V2 ND	Boxing Group	21.63 ± 6.72	- 8.22	<.001
	Handball Group	29.86 ± 6.56	(-12.87 / -3.57)	
PPT-V3 D	Boxing Group	20.86 ± 7.39	- 6.40	.003
	Handball Group	27.27 ± 5.60	(-11.03 / -1.77)	
PPT-V3 ND	Boxing Group	20.85 ± 6.51	- 6.77	.005
	Handball Group	27.63 ± 7.49	(-11.42 / -2.13)	
PPT-M D	Boxing Group	16.04 ± 4.88	- 11.16	<.001
	Handball Group	27.21 ± 5.39	(-14.75 / -7.57)	
PPT-M ND	Boxing Group	16.52 ± 4.90	- 10.22	<.001

	Handball Group	26.74 ± 5.22	(-13.76 / -6.67)	
PPT-TA D	Boxing Group	82.25 ± 17.16	- 1.49	.958
	Handball Group	83.75 ± 16.52	(-10.67 / 13.65)	
PPT-TA ND	Boxing Group	81.79 ± 17.25	- 2.23	.453
	Handball Group	84.03 ± 17.22	(-14.68 / 10.20)	
Helkimo test	Boxing Group	7.44 ± 4.00	3.63	.008
	Handball Group	3.81 ± 2.25	(1.32 / 5.88)	

* Data are expressed as mean ± standard deviation (SD) or as mean (95% CI, confidence interval). PPT values are expressed in N/cm^2

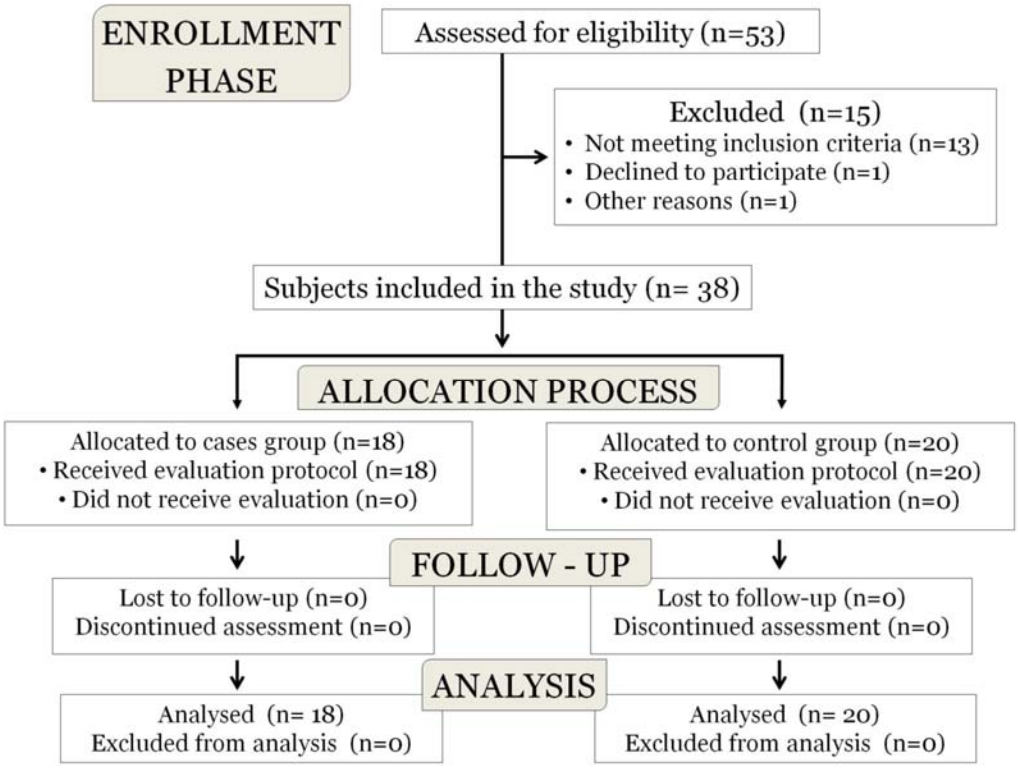
Abbreviations: HIT-6, Headache Impact Test-6; PPT, pressure pain threshold; V1, supraorbital nerve; V2, infraorbital nerve; V3, mental nerve; M, masseter muscle; TA, tibialis anterior muscle; D, dominant side; ND, non-dominant side

Table 3 Frequency distribution of the study subjects based on the scores of the HIT-6 and the HCI*

Observed events (N=38)	Boxers (n=18)	Controls (n=20)	p value
HIT-6 not disabling (<50)	8 (21.0)	16 (42.1)	.023
HIT-6 slight (50-55)	8 (21.0)	2 (5.2)	.016
HIT-6 moderate (56-59)	2 (5.2)	2 (5.2)	.911
HIT-6 severe (>59)	0 (0)	0 (0)	1.00
HIT-6 > slight	10 (26.3)	4 (10.5)	.023
HCI slight (<5)	4 (10.5)	11 (28.9)	.139
HCI moderate (5-9)	8 (21.0)	8 (21.0)	.516
HCI severe(≥10)	6 (15.7)	1 (2.6)	.024
HCI > slight	14 (36.8)	9 (23.6)	.039

* Data are reported as number of subjects and (frequency, %, of total sample, N); p-value, sourced from the Chi Square test (X^2).

Abbreviations: HIT-6, Headache Impact Test-6; HCI, Helkimo Clinic Index


ENROLLMENT PHASE
Assessed for eligibility (n=53)
Excluded (n=15)
• Not meeting inclusion criteria (n=13)
• Declined to participate (n=1)
• Other reasons (n=1)
Subjects included in the study (n= 38)
ALLOCATION PROCESS
Allocated to cases group (n=18)
• Received evaluation protocol (n=18)
• Did not receive evaluation (n=0)
Allocated to control group (n=20)
• Received evaluation protocol (n=20)
• Did not receive evaluation (n=0)
FOLLOW - UP
Lost to follow-up (n=0)
Discontinued assessment (n=0)
Lost to follow-up (n=0)
Discontinued assessment (n=0)
ANALYSIS
Analysed (n= 18)
Excluded from analysis (n=0)
Analysed (n= 20)
Excluded from analysis (n=0)