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INFLUENCE OF CHOKING AND ARM LOCK TECHNIQUE IN JUDO ON THE ACOUSTIC REFLEX THRESHOLD (ART) IN HEALTHY WELL-TRAINED MALE AND FEMALE JUDOKA

CHRISTOPH RASCHKA[1], HORST JOSEF KOCH[2] and RÜDIGER RAU[3]

[1]*Institute of Sports Medicine, Frankfurt, Germany*
[2]*Department of Psychiatry, University Hospital Regensburg, Germany*
[3]*Public Health Department for the District Wesel, City of Moers, Germany*

Summary

The objective of this controlled parallel group study was to assess the effects of standardized choke holds (test) and arm lock techniques (controls) in on the acoustic hearing threshold. 104 (test group, 32 female subjects and 72 male subjects, mean age = 28.0 years, SD = 7.9 years) and 51 experienced judoka (controls, 21 female subjects, 30 male subjects; mean age = 26.8 years; SD = 13.2 years) participated. Acoustic reflex thresholds (ART [dB]) were measured separately before and after each manoeuvre both for air and bone conduction of the right and left side. The difference Dart of the ART before and after a manoeuvre (Dart = ARTbefore – ARTafter) was calculated. Data were presented descriptively and nonparametric statistics was applied for nonrelated (Kruskal Wallis ANOVA) or related samples (Friedman ANOVA). Wilcoxon tests were used for pre/post comparisons of original ART values.

The effect of choking on Dart was significantly different from the effect of the arm lock technique on Dart independent of the experimental condition. A significant influence of applied frequencies on Dart was ascertained if a choking technique was used. For all frequency ranges applied a highly significant improvement of the ART after choking was found. With regard to bone conduction thresholds increased by an average of 6.1 dB and for air conduction the average increase was 4.9 dB. On the contrary, arm locks induced a slight mean deterioration of the ART for bone conduction of 1.8 dB. The ART for bone conduction also showed a trend towards a reduction after arm locks with a mean decrease of about 1.2 dB. In conclusion, standardized choking manoeuvres reduced the ART corresponding to an improved hearing both with regard to air and bone conduction. Such an effect on hearing ability was not found for arm lock techniques.

Key Words: Judo, choking, arm lock, audiometry, acoustic reflex threshold

Introduction

Judoka occasionally reported that they experienced a state of high alertness, keenness of sight and hearing and even a feeling of serenity after being choked. On the contrary, observations from previous studies indicate that choking rather leads to a temporary cerebral

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Address for correspondence:
Dr.med. Dr.rer.nat. Dr./Univ. Zürich Horst J. Koch DCPSA MFPM
Psychiatric University Clinic, Dept. of Gerontopsychiatry, Universitätsstrasse 84, 93053 Regensburg
Tel: 0941-941-0 Fax: 0941-941-1205
Email: horst.koch@bkr-regensburg.de

hypoxia[1,2,3] accompanied by a transient reduction of central activation and performance of perception. In a controlled study on nine experienced first league judoka in whom intracranial blood flow velocity was measured in the mid cerebral artery at rest and during a typical choking manoeuvre (Shime-waza) in judo by means of transcranial Doppler-sonography[2]. Cross-choking (Juji-jime) manoeuvres were applied and no fainting was observed. One subject reported a hemidysaesthesia on his right side, which was reversible immediately. The middle end-diastolic flow in the mid cerebral artery (MCA) sank from 37.9 cm/s (SD = 7.8) to 4.2 cm/s (SD = 4.3; $p < 0.01$). In 4 of the 9 participating judoka the end-diastolic flow during choking could even not be detected anymore. Ear-pulse-oxymetry showed a significant decrease from 97.9 % (SD = 1.8) to 93.2 % (SD = 4.1). No correlation between anthropometric parameters (type of constitution, circumference of the neck) and the results of the flow investigation could be ascertained. In order to detect even subclinical brief alterations of brain function, another study was conducted in 6 experienced judoka and EEG-changes after choking were assessed by spectral analysis[4]. Once again, the cross-choking-technique "Juji-jime" was used. Marked changes occurred within the low frequency ranges, the delta and theta bands, in the form of significant increase of global field power. At the same time a significant decrease of power in the alpha band was detected. After choking for an average time of 8 s these changes reached significance up to 20 s after the manoeuvre.

The objective of this study was to assess the effect of a standardized choking manoeuvre on the acoustic reflex threshold (ART) compared to corresponding effects of arm lock techniques and to discuss possible underlying physiological principles.

Methods and Materials

Volunteers

The effect of a standardised choking manoeuvre on hearing was studied in 104 experienced judoka (32 women, 72 men; mean age 28.0 years; SD = 7.9 years; range 18 – 42 years) and was compared with a group of 51 subjects (21 women, 30 men; mean age 26.8 years; SD = 13.2 years) who were exposed to a standardised arm lock technique. The study was approved by the Board of the Dept. of Sports Sciences and written informed consent was obtained beforehand by all subjects who were familiar with all kinds of choking manoeuvres.

Choking manoeuvre and arm-lock technique

The choking person approached the subject from fronto-lateral, got hold of the upper parts of the "Judo Gi's" (cotton jacket worn in Judo) lapel, and started choking by turning both hands and forearms inwardly while pulling his arms to his body. This manoeuvre leads to a continuous compression of the ventral parts of the neck thus affecting the main head-neck-vessels (carotids and jugular veins). As soon as the subject gave a sign by tapping with the flat of his hand, choking was stopped. Choke holds were performed by a very skilled black-belt judoka with experience on this level for more than 5 years. Only one routine choking technique was applied (kata-juji-jime) under controlled conditions. During choking as well as during audiometry all subjects were sitting in a relaxed position. In addition, only one judogi was used for the experimental choking manoeuvre to avoid differences in material. Each of the subsequent four standard choke holds lasted from at least 6 s to a maximum of 8 s and no fainting occurred.

In the control group of the present study a lateral "bar-stretch-lock" (Munekan-nuki) was applied. With his right hand, Tori (the attacker) got hold of Uke's (the attacked person) left wrist.

Tori then moved his left hand beneath Uke's left ellbow in order to grab his own forearm. By pushing his left forearm against Uke's ellbow, Tori exerted leverage. This standard arm lock technique was also repeated four times followed by audiometric recordings.

Study design and statistics

The study followed a controlled, randomised, parallel group design with 104 test (subjects who were allocated to the standard choking manoeuvre) and 51 control (subjects who were allocated to the standard arm lock technique) subjects to assess the objective whether choking or arm lock techniques differ with regard to acoustic reflex thresholds (ART [dB]). The key characteristic for statistical analysis of test group (subjects following choking technique) versus control group (subjects following arm lock technique) was the difference of ART before and after (Dart) the respective manoeuvre:

Dart = ART before – ART after manoeuvre [dB]).

All statistical analysis was done with StatisticaR Version 5.0, commercially available Statsoft, Tulsa, USA or AxumR Version 6.0, commercially available Mathsoft, Seattle, USA. All data were presented descriptively as whisker plots (medians, non-outlier ranges acc.[5] with test and control values separately for air or bone conduction of each side as a function of applied frequencies. A two way nonparametric ANOVA for independent samples (Kruskal-Wallis test) was applied for air conduction and bone conduction of the right and left side, respectively. Subsequent multiple comparisons were done by means of Nemenyi tests for unrelated samples[6]. As a secondary objective the influence of the various frequencies (within-group comparison) on hearing ability (Dart) was assessed by means of a nonparametric one way Friedman ANOVA. Moreover, explorative Wilcoxon tests for related samples were used to compare initial ART values with those after a manoeuvre, i.e. pre/post comparison of original data[7]. A p-value lower than 0.05 was generally considered as significant. With regard to a parametric (nonparametric test has approximately 95% of the power) two way ANOVA model a power of 80 % requires a sample size of approximately 30 subjects in each group (significance level = 0.05, effect size = 0.25 [difference of means/SD]). The pre/post comparison by means of the Wilcoxon test needs approximately 40 subjects to show a difference of 5 units with a power of 80 % (SD=10, alpha=0.05)[8].

Audiometer and audiometric recording

In this study a transportable audiometer (Selector 20 K) with a weight of 1.8 kg was used. Its size (width × height × depth) was 330 × 85 × 250 mm. The following test-frequencies in air-conduction were examined: 250, 500, 750, 1000, 2000, 3000, 4000, 6000 and 8000 Hz; for bone-conduction 6000 and 8000 Hz-frequencies could not be measured (exactness of frequencies ≤ 1 %). Tests were carried out with an air-headphone (Holmberg-type 8103) and a bone-headphone (Radio ear B 71). Maximum levels of loudness in terms of ML (meuring level) ranged between 100 and 120 dB. The manufacturer of the used equipment is the neuro-otometric company Hortmann AG (Robert-Bosch-Str. 6; 72645 Neckartenzlingen, Germany). In order to find acoustic reflex thresholds (ART) dB-keys were operated: every time the key is pressed, loudness is changed by 5 dB. The subject had to give a sign, as soon as he or she heard a sound. As a standard a continuous tone (continuant) was presented to each subject.

Before each test the subject heard a continuous tone above the acoustic reflex threshold, so he was prepared for the examination. Increase of loudness was done slowly, each sound was presented for at least half a second at the chosen volume-level. In order to facilitate visual contact between the investigating person and the subject, subjects were seated in a position slightly diagonal opposite to the examining person. After measuring the acoustic reflex threshold for air-conduction, bone-conduction was measured on both sides within the above mentioned frequencies. The bone-headphone was positioned upon the mastoid while the bow (side-piece) was placed above the contralateral temple. The bone-headphone emits/radiates soundwaves by air, which the subject might hear, louder and better through the open auditory canal than the actual bone-conducted sound. To avoid this effect, which depends on the loudness of sound and of the individual subject, ear-plugs were put into both ears of the subject.

All measurements were carried out in a small, noise-free side room of a gymnasium shortly before regular evening judo training according to a defined schedule. Audiometry was first carried out under conditions of rest. After choking (Juji-jime) thresholds of air-conduction were measured on the right side for all mentioned frequencies within 6 minutes after the choking manoeuvre. After a break of 15 minutes choking was repeated and thresholds of air conduction were measured in the left ear. After another 15 minutes break the choke hold was repeated, followed by measurement of bone-conduction on the right side, and after the fourth choking manoeuvre, the left ear was tested. The audiometric recording for the arm-lever technique was the same as used for choking.

Results

During the study no complaints or fainting of the participants were reported after choking or arm lock manoeuvres. In Figures 1 to 4 the influence of test (choke holds) and control (arm locks) manoeuvres on the difference Dart between the corresponding audiometric measurement before and after the manoeuvre are presented as whisker plots (median/non-outlier maximum) separately for air or bone conduction of the right and left side. Generally, choke holds provoked more marked decrease of acoustic reflex thresholds compared to arm locks, i.e. choke holds improved the hearing. The difference between the parallel test and control groups were highly significant (Kruskal-Wallis, p-values$<$0.01) for all experimental conditions. This result was also confirmed by nonparametric post hoc multiple comparisons of unrelated samples (Nemenyi tests, p-values$<$0.01). The results of the Friedman ANOVA for related samples (within-group comparison) are presented in Table 1. The frequency applied influenced the difference Dart in the test group (choke hold) both for air and bone conduction. Significant differences of Dart with regard to applied frequencies were not found when the volunteers were exposed to the standardised arm lock technique.

The results of the explorative matched pair Wilcoxon tests (pre/post comparisons) are summarized in Table 2. In all frequency ranges measured a highly significant improvement of the ART values ($p \leq 0.001$) after exposure to choking techniques was found in the present study. With regard to bone conduction thresholds raised by an average of 6.1 dB and for air-conduction the average value amounted to 4.9 dB. These changes in direction were most pronounced in the lower frequency ranges on both sides.

A completely different trend was observed in the course of the control trial using arm locks. Here, a slight deterioration of the acoustic reflex threshold for bone conduction occurred on an average of 1.8 dB. In approximately one third of the measurements no significance was ascertained. ART values for bone-conduction, too, showed a trend towards a reduction after the application of arm lock manoeuvres. On an average, the values decreased by 1.2 dB, but in the majority (approximately two thirds) of the cases these changes did not reach the statistically significant level.

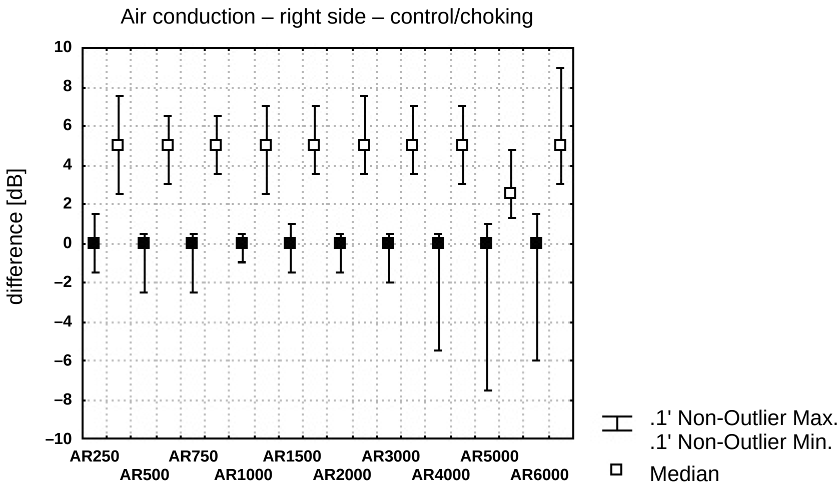

Figure 1 Whisker plots (median, non-outlier range) of air conduction (right side) of the difference Dart = ARTbefore – ARTafter [dB] versus frequency [Hz] comparing influence of a standardized choking manoeuvre (upper row of whiskers, positive difference denotes improvement of hearing) with the effect of a standardized arm lock techniques (lower row of whiskers, filled).

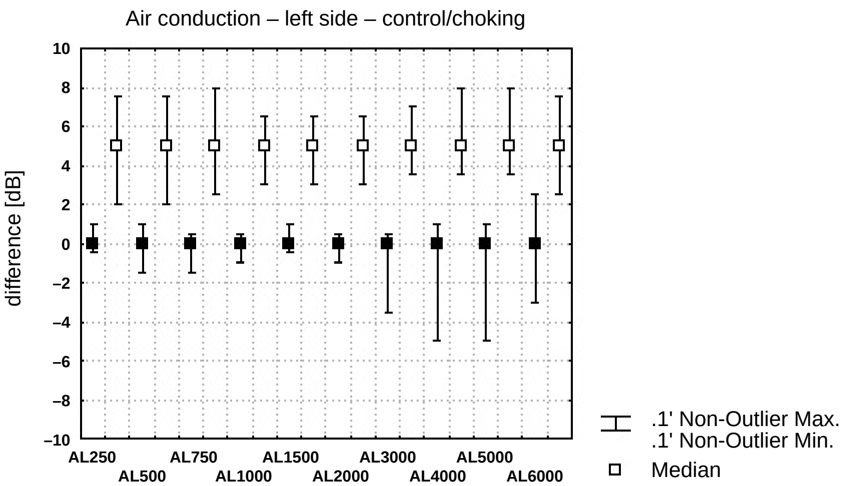

Figure 2 Whisker plots (median, non-outlier range) of air conduction (left side) of the difference Dart = ARTbefore – ARTafter [dB] versus frequency [Hz] comparing influence of a standardized choking manoeuvre (upper row of whiskers, positive difference denotes improvement of hearing) with the effect of a standardized arm lock techniques (lower row of whiskers, filled).

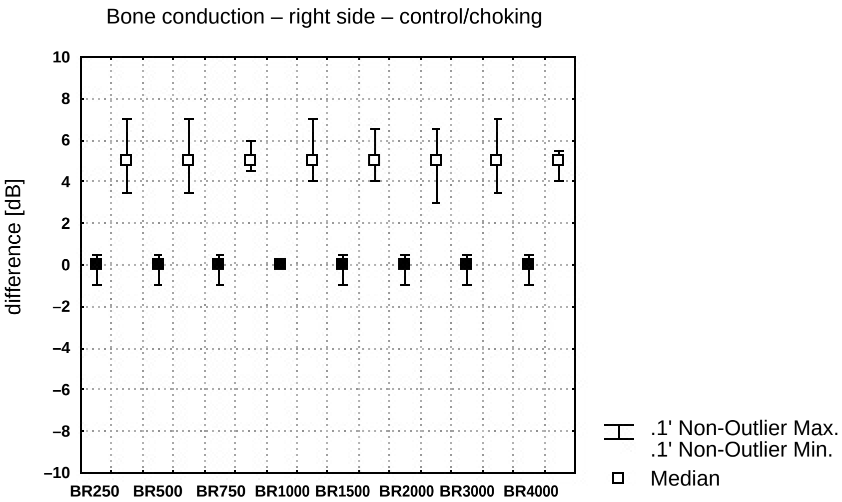

Figure 3 Whisker plots (median, non-outlier range) of bone conduction (right side) of the difference Dart = ARTbefore – ARTafter [dB] versus frequency [Hz] comparing influence of a standardized choking manoeuvre (upper row of whiskers, positive difference denotes improvement of hearing) with the effect of a standardized arm lock techniques (lower row of whiskers, filled).

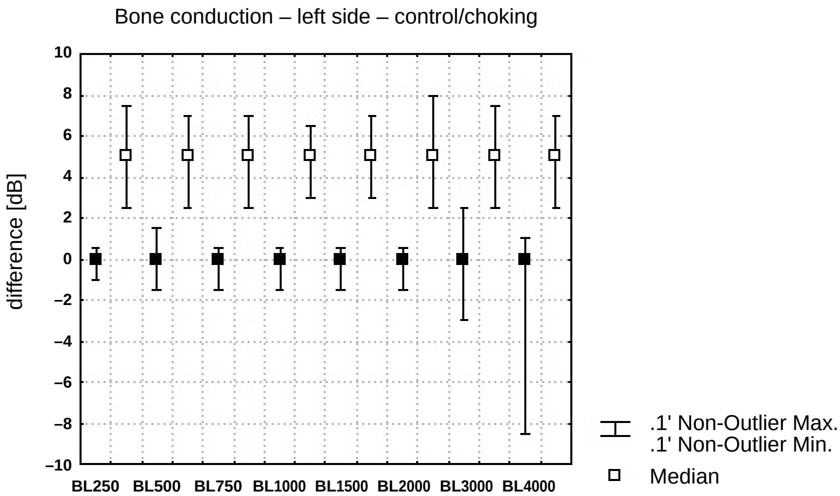

Figure 4 Whisker plots (median, non-outlier range) of bone conduction (left side) of the difference Dart = ARTbefore – ARTafter [dB] versus frequency [Hz] comparing influence of a standardized choking manoeuvre (upper row of whiskers, positive difference denotes improvement of hearing) with the effect of a standardized arm lock (lower row of whiskers, filled).

Table 1. Results of one way Friedman ANOVA assessing the influence of frequencies on the difference Dart. The corresponding p-values are given for air and bone conduction.

	Choking manoeuvre		Arm lock manoeuvre	
	Air conduction	Bone conduction	Air conduction	Bone conduction
Right side	0.027	0.007	0.852	0.443
Left side	0.021	0.061	0.259	0.205

Table 2. P-values of explorative Wilcoxon tests (pre/post comparisons of audiometry values) following standardized arm lock manoeuvres for both air and bone conduction of right and left side. Corresponding p-values for the choking manoeuvres were generally smaller than 0.0001 and are therefore not depicted.

Frequency	Air conduction		Bone conduction	
[Herz]	Right	Left	Right	Left
250	0.778	0.251	0.027	0.351
500	0.077	0.092	0.020	0.052
750	0.010	0.024	0.210	0.008
1000	0.011	0.239	0.234	0.074
1500	0.276	0.510	0.049	0.001
2000	0.044	0.248	0.003	>0.000
3000	0.041	0.245	0.009	0.014
4000	0.010	0.024	0.210	0.008
6000	0.156	0.126	–	–
8000	0.112	0.038	–	–

Discussion

It was the aim of this study to assess the consequences of choke holds on hearing ability as such choking techniques (Juji-jime) belong to the standard repertoire of Judo. Previously made studies using Doppler ultrasound and brain mapping[2,3] demonstrated that it has become possible to deliver an extensive description and evaluation of neurological and psychophysiological effects induced by choke holds. Other studies documented grades of activation before, during and after choking on endocrine, vegetative and central nervous levels[9]. In spite of a presumable habituation due to years of experience, choking still provokes a pronounced stress reaction in Judokas, which manifests with different latencies but tending towards the same direction in the alteration of physiological parameters (catecholamines, cortisol, skin conduction level, spectral analysis of electroencephalography [EEG]). It is remarkable that stress reactions already started briefly before choking, which might be due to classic conditioning[9]. Choking causes a central hypoxia accompanied by corresponding losses of performance (Flicker Fusion Frequency, EEG spectral analysis, Doppler ultrasound), lasting at least for 20 s, presumably, however, up to several minutes.

The present study, however, yielded results which appear incompatible with a model of reduced physiological performance of central nervous processes induced by hypoxia. It is remarkable that in all measured frequencies of hearing ability a statistically highly significant improvement of acoustic performance after choking could be recorded and no decrease of hearing occurred. On the contrary, the stimulus of pain induced by the arm lock techniques did not lead to an improvement but rather to a slight loss of hearing performance. It remains unclear, whether this stress-induced alteration of acoustic perception is due to an improvement of central nervous processing of acoustic signals or whether it is due to changes of performance of peripheral sense organs. Finally, all factors which improve hearing must relax the stapedius muscle, while factors which deteriorate hearing relax the M. tensor tympani and vice-versa. Theoretically, inhomogenieties of cerebral blood flow with regard to cortex and ear, an arousal due to pain or hypoxia or a slight rebound of perfusion due to prior hypoxia may be underlying mechanisms.

The release of epinephrine in the adrenal medulla, which the authors described in previous studies[1,9], may be relevant for the improved hearing. Moreover, cortisol secretion obviously exerts a suppressive effect on defence reactions[10]. Supposing a suppressive effect of corticosteroids in alarm reactions, it is not surprising that pain induced stress reactions during the exertion of arm locks, which is not a life-threatening event, did not change the ART very much. This assumption corresponds to the results of Beckwith *et al.*[11], who found a specific increase of thresholds in the high frequency range after administration of 20 mg hydrocortisone. In examining 15 healthy male subjects Fehm-Wolfsdorf[12], however, did not find any change in acoustic thresholds after having substituted 50 mg hydrocortisone or 2 mg dexamethasone. In this context, the influence of day time should not be omitted. In the present study as well as in the investigation by Beckwith *et al.*[11] investigations were done in the evening, both showing lower acoustic reflex thresholds, whereas Fehm-Wolfsdorf[12] conducted the study in the morning.

In the present study choking induced a different response (improvement of hearing performance) than arm locks (reduction of hearing performance) in healthy athletes familiar with both techniques. The relevance of stress reaction and transient hypoxia cannot be assessed definitely and awaits elucidation in future investigations.

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