

# Effects of Choking Manoeuvres in Judo (Juji-Jime) on Pulmonary Function Parameters in Young, Well-trained Athletes

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**Summary.** The following parameters were measured by means of a spirometer for 13 female and 49 male subjects (Judoka, experienced in competition with a mean age of 27.6 yrs, sd=10.3 yrs) before and immediately after crosshanded choking (Juji-jime): FVC, FEV 1, FEV1/FVC, FEF 25–75, PEF, PIF, MEF 75, MEF 50, MEF 25, VC, IC, TV, IRV, ERV, and MVV.

Significant changes were seen in FVC, which was reduced in an order of 0.24 l, in FEV1, which decreased by 0.36 l, in the ERV, which was reduced by 0.23 l, and the MVV, which decreased by 6.3 l/min. The VC showed a slight reduction of approximately 0.1 l after choking, and FEV1/FVC-ratio increased in an order of 1%. None of the other recorded parameters showed any clinically relevant alterations. In conclusion, there was no indication that choking provoked an airway obstruction. Protective factors such as a high release of cortisol before choking as part of a general stress-response should be discussed.

**Key words**—Crosshanded choking, lung function, spirometry, static and dynamic parameters.

## INTRODUCTION

Choke holds in Judo do not primarily impede respiratory function, but rather lead to a cerebral ischemia

due to a compression of both carotid arteries, as was clearly demonstrated by Doppler-studies on mid cerebral and carotid arteries (Raschka et al., 1996 & 1998) as well as in brain-mapping-studies using shime-waza (Rau et al., 1998). This explains why there have been no reports in serious injuries of the larynx or trachea in the past. Stroke as a complication of choking in Judo, however, was reported by Røsjø and Sortland already in 1987: the subject developed aphasia and a right-sided hemiplegia a few hours after experiencing choking techniques.

In contrast, choke holds applied in self-defence and routine police action do quite often cause fatalities. In 1987, Koiwai found on 14 fatalities due to carotid artery control choke holds. In all 14 cases, the author noted evidence of serious injuries to the structures of the neck, with fractures of larynx cartilage present in 5 cases and lesions of mucosa and submucosa found in 5 other cases.

The present study thus investigates whether accurately exerted choke-holds (katajuji-jime) may lead to clinically relevant alterations of the airways, which can be detected by routine spirometry techniques.

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**Abbreviations**—FVC, forced expiratory vital capacity; FEV 1, forced expiratory volume within 1 second; FEV1/FVC, relative 1-Second-Capacity as a ratio of FEV1 and FVC; FEF 25–75, maximum average expiratory flow; PEF, peak expiratory flow=maximum velocity of exhalation; PIF, peak inspiratory flow; MEF 75,

maximum expiratory flow at 75% of vital capacity; MEF 50, maximum expiratory flow at 50% of vital capacity; MEF 25, maximum expiratory flow at 25% of vital capacity; VC, non-forced vital capacity; IC, inspiratory capacity; TV, Tidal volume; IRV, inspiratory reserve volume; ERV, expiratory reserve volume; MVV, maximum voluntary ventilation within one minute; SD, standard deviation.

## METHODS

The following lung function parameters (Ulmer et al., 1986) were measured in 13 female and 49 male well-trained volunteers (judoka, experienced in competition with mean age of 27.6 yrs,  $sd=10.3$  yrs) in an open within-subject design before and immediately after crosshanded choking (Juji-jime), which was performed in the evening prior to regular judo-training (Device: Autospiro AS 500R; Minato, Japan): FVC (Forced Expiratory Vital Capacity), FEV 1 (Forced Expiratory Volume within 1 sec), FEV1/FVC (relative 1-Second-Capacity as a ratio of FEV 1 and FVC), FEF 25-75 (maximum average expiratory flow), PEF (Peak expiratory flow=maximum velocity of exhalation), PIF (peak inspiratory flow), MEF 75 (maximum expiratory flow at 75% of vital capacity), MEF 50 (maximum expiratory flow at 50% of vital capacity), MEF 25 (maximum expiratory flow at 25% of vital capacity), VC (non-forced vital capacity), IC (inspiratory capacity), TV (Tidal volume), IRV (inspiratory reserve volume), ERV (expiratory reserve volume), and MVV (maximum voluntary ventilation within one minute). All results were presented descriptively including Median/Range or Mean/SD, and corresponding box plots (median, 25/75% percentiles) were given for effect variables. Effect variables were calculated as follows:  

$$\text{Effect} = \{(\text{Value before} - \text{Value after}) / \text{Value before}\} * 100[\%]$$

Pairwise nonparametric Wilcoxon tests for related samples were used to assess differences of values before and after choke holds, and corresponding p-values were calculated (Zar, 1984). Simple pairwise linear correlation analysis was done to assess relations between height and initial spirometric characteristics. Critical values for correlation coefficients based on an F-statistic were taken from Zar (1984). Generally, p-values smaller than 0.05 were considered significant. StatisticaR (Statsoft, Tulsa, USA) was used for statistical calculations.

The choking manoeuvre was done in a standardized manner by one identical experienced judoka (black belt). Briefly, the attacker 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 inward, while pulling his arms to his body. By exerting this manoeuvre, a continuous compression of the ventral parts of the neck is performed, thus affecting the main head-neck-vessels (carotids and jugular

veins). The choking procedure could be stopped at once, if requested, so that no subject fainted. The choking manoeuvre listed an average 8 s (range 6-10 sec) without substantial differences between male and female subjects.

## RESULTS

All choke holds were well tolerated by the volunteers and no complaints were reported within 304 min after the test. The results of the descriptive analyses and Wilcoxon tests are summarized in Table 1. Significant changes were seen in FVC, which was reduced in an order of 0.24 l, and in FEV1, which decreased by an order of 0.36 l. Furthermore, the ERV was significantly reduced by 0.23 l as was the MVV, which decreased by 6.3 l/min. In contrast, the VC showed a slight non-significant reduction of approximately 0.11 after choking. The FEV1/FVC-ratio increased in an order of 1% ( $p>0.05$ ). All other lung function parameters recorded in the study did not show either significant or clinically relevant changes due to the choking manoeuvre.

The effect variable of those parameters which showed significant changes after the choking manoeuvre are presented in Fig. 1 as box plots. Obviously, there was a marked variability among ERV values, although median change with regard to the initial value was approximately 10%. After choking the median change of FEV1, FVC or MVV was within an order of 3 to 4%, interindividual variability being lower compared to the variability in ERV values. Significant correlations between height or age and lung function parameters are given in Table 2. The closest correlation was found between FVC versus height ( $r=0.74$ ), and the corresponding scattergram is presented in Fig. 2. In general, particularly static lung function parameters such as FVC or VC were significantly correlated with height. With regard to the age variable, only MEF25 values showed significant correlation coefficients. No differences between gender were found with regard to the effect of choke holds on respiratory characteristics.

## DISCUSSION

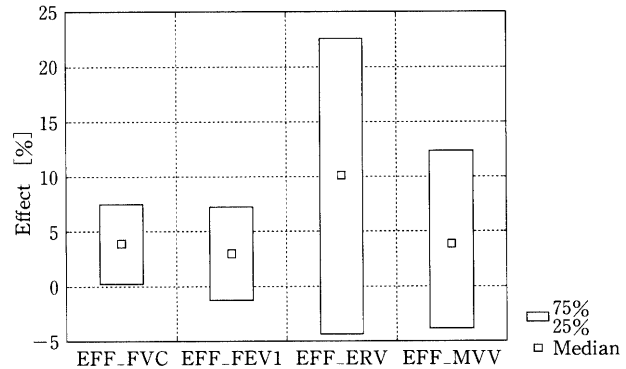
The range of recorded static and dynamic variables of pulmonary function corresponded to reference data, which have been documented in students of sports sciences with an average of 5 hours of physical exercise per week (Hoffmann, 1997). The most

**Table 1.** Table of median/range and mean/sd values of spirometry characteristics before and after choking

| Parameter<br>(unit) | Median<br>(range) | Median<br>(range) | Mean<br>(SD)     | Mean<br>(SD)     | p-values |
|---------------------|-------------------|-------------------|------------------|------------------|----------|
|                     | before            | after             | before           | after            |          |
| FVC<br>(l)          | 4.85<br>( 4.05)   | 4.63<br>( 3.68)   | 4.80<br>( 0.89)  | 4.57<br>( 0.88)  | <0.001   |
| FEV1<br>(l)         | 3.91<br>( 3.96)   | 3.75<br>( 4.05)   | 4.12<br>( 0.81)  | 3.76<br>( 0.79)  | 0.001    |
| FEV1/FVC<br>(%)     | 84.6<br>(57.1)    | 84.6<br>(60.3)    | 82.1<br>(11.3)   | 82.6<br>(10.8)   | n.s.     |
| FEF 25-75<br>(l/s)  | 4.14<br>( 6.02)   | 4.09<br>( 5.26)   | 4.27<br>( 1.32)  | 4.15<br>( 1.23)  | n.s.     |
| PEF<br>(l/s)        | 6.89<br>(10.24)   | 6.61<br>(10.25)   | 6.95<br>( 2.41)  | 6.79<br>( 2.32)  | n.s.     |
| PIF<br>(l/s)        | 4.08<br>( 8.92)   | 3.75<br>(11.4 )   | 3.75<br>( 2.40)  | 3.81<br>( 2.66)  | n.s.     |
| MEF 75<br>(l/s)     | 6.41<br>( 8.16)   | 6.26<br>( 8.4 )   | 6.21<br>( 2.05)  | 6.12<br>( 1.94)  | n.s.     |
| MEF 50<br>(l/s)     | 4.75<br>( 6.28)   | 4.50<br>( 6.15)   | 4.80<br>( 1.55)  | 4.62<br>( 1.40)  | n.s.     |
| MEF 25<br>(l/s)     | 2.37<br>( 3.95)   | 2.50<br>( 3.84)   | 2.47<br>( 0.94)  | 2.43<br>( 0.92)  | n.s.     |
| VC<br>(l)           | 5.18<br>( 4.15)   | 4.85<br>( 3.62)   | 4.97<br>( 0.98)  | 4.87<br>( 0.90)  | n.s.     |
| IC<br>(l)           | 3.32<br>( 4.31)   | 3.33<br>( 3.49)   | 3.32<br>( 0.96)  | 3.37<br>( 0.83)  | n.s.     |
| TV<br>(l)           | 0.89<br>( 2.37)   | 0.96<br>( 2.70)   | 0.96<br>( 0.54)  | 1.05<br>( 0.53)  | n.s.     |
| IRV<br>(l)          | 2.42<br>( 4.21)   | 2.32<br>( 4.11)   | 2.35<br>( 0.97)  | 2.32<br>( 0.87)  | n.s.     |
| ERV<br>(l)          | 1.62<br>( 2.78)   | 1.33<br>( 3.00)   | 1.69<br>( 0.68)  | 1.46<br>( 0.58)  | 0.008    |
| MVV<br>(l/min)      | 128.9<br>(157.9)  | 119.9<br>(141.7)  | 127.3<br>( 38.2) | 121.0<br>( 38.0) | 0.008    |

n.s.,  $p > 0.05$ .

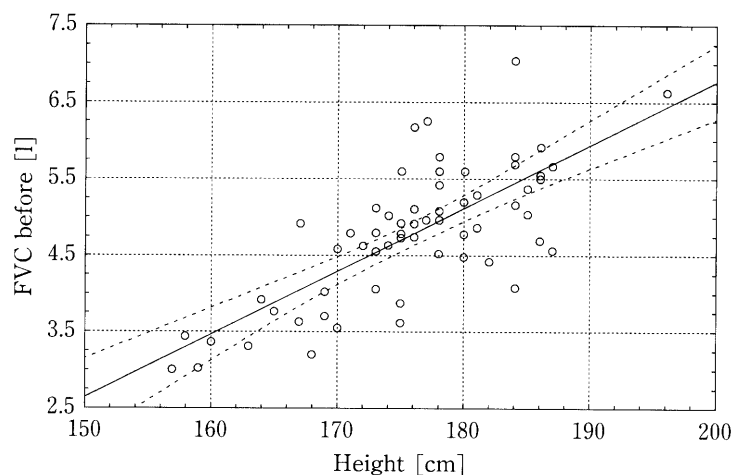
remarkable finding of the present study lies in the fact that state-of-the-art choke-holds in Judo do not lead to a clinically relevant pulmonary obstruction. Probably, the release of cortisol, which was not determined in this study, before choking as part of a general stress response exerts a pronounced bronchodilating anti-obstructive effect. Stress responses due to pain or emotional influences have been well known for almost a century (Cannon, 1914). In addition, Mangold and Raschka (1999) showed that cortisol and catecholamine levels rise prior to and after

**Fig. 1.** Box plots –effect variables. Box plots (median [□] and 25-75 percentiles [□]) of effect variables of FVC, FEV1, ERV and MVV.**Table 2.** Results of pairwise correlation analysis between lung function parameters and either height or age

| Parameter | Height  | Age     |
|-----------|---------|---------|
| FVC       | 0.74*** | -0.02   |
| FEV1      | 0.55*** | -0.19   |
| FEV1/FVC  | -0.23   | -0.19   |
| FEF 25-75 | 0.16    | -0.23   |
| PEF       | -0.28*  | 0.17    |
| PIF       | 0.12    | -0.07   |
| MEF 75    | 0.26*   | 0.15    |
| MEF 50    | 0.17    | -0.16   |
| MEF 25    | 0.05    | -0.40** |
| VC        | 0.57*** | 0.13    |
| IC        | 0.31**  | 0.05    |
| TV        | 0.09    | 0.03    |
| IRV       | 0.26*   | 0.03    |
| ERV       | 0.37**  | 0.09    |
| MVV       | 0.34**  | 0.15    |

\*,  $p < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$ .

choking manoeuvres. This observation is also supported by the fact that no significant changes in “air current velocity” in the small airways were recorded. The possible role of anxiety, which often triggers asthmatic symptoms within an interval of some 10 min. (Nolte, 1991; Uexküll, 1997), is possibly antagonised by the hormonal changes, as no obstruction was observed within 30 min. after the test. Additional investigations are necessary, however, to back this hypothesis.



**Fig. 2.** Scatterplot—FVC before choking vs. height incl. 95% -CI.  
 $Y = 9.866 + 0.083 \times X$  ( $r = 0.74$ ).

Scattergram and linear regression line including 95% CI of FVC versus height. The equation of the regression line is:  $Y = 0.083 \times X - 9.866$  ( $r = 0.74$ ).

The highly significant reduction in MVV values as well as the reduction in the static pulmonary volumes may cautiously be interpreted as the consequence of shallow breathing in subjects under stress. The slight insignificant increase in airway-resistance as assessed by means of peak-flow in this study is in keeping with reduced extent of respiration.

If we compare the results of the present study with those from Koiwai's autopsy study, the following substantial differences can be seen: The pressure directed to the superior carotid triangle needs to be no more than 300 mm Hg to cause unconsciousness in an adult. This indicates that a choke hold properly performed by a female can render unconscious a male twice her size, even without excessive strength. If the carotid artery hold is properly applied, unconsciousness occurs in approximately 8–14 s according to Koiwai (1987). A neck pressure of 250 mmHg or of 5 kg of rope tension is required to occlude the carotid arteries. The pressure required to compress airways is six times greater. In judo, the player tries to obstruct the blood flow of the common carotid artery, whereas complete closure of the trachea will result in irreversible damage. Some of the victims in Koiwai's study probably showed greater tolerance for pain due to drugs and alcohol. All 14 cases revealed injuries to neck structures from bruises, ecchymosis, or hemorrhages following fractures of the cartilage of the neck in 5 cases, the intervertebral disc in one case, and submucosal or mucosal injuries in the larynx in 5 cases, indicating that tremendous forces

were exerted on the necks of the subjects.

In conclusion, the results of this study show that, provided the rules of the Judo Federation are observed, choking in Judo, does not entail any risk of inducing obstructions of the airways. If, however, choke holds are exerted by persons without experience, especially in case of uncontrollable factors such as violence, serious injuries of sensitive larynx-structures can occur.

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