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Original Article

Association of Obstructive Sleep Apnea Syndrome with Trapezius Muscle Hardness

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ABSTRACT

Background: Neck-shoulder stiffness (NSS) is a common condition that has a variety of clinical presentations, *e.g.*, muscular tension around the shoulders, and can affect quality of life. Muscle hardness (MH) is often evaluated to assess NSS. Although reports have suggested an association with sleep disturbance, the relationship of NSS with obstructive sleep apnea syndrome (OSAS) is unclear.

Methods: To investigate OSAS, 100 patients underwent polysomnography. To investigate the association between NSS and polysomnography data, the MH of the trapezius muscle was measured bilaterally above the shoulders before and after polysomnography.

Results: Fifty-three patients had NSS. MH was significantly lower after polysomnography on both sides. As compared with patients with an apnea hypopnea index lower than 20, those with an apnea hypopnea index of 20 or higher had a significantly smaller reduction in MH on both sides, and a significantly higher MH on the left side, after polysomnography. Change in MH on the right side was weakly inversely correlated with apnea hypopnea index, arousal index, 3% oxygen desaturation index, and %stage 1 sleep and weakly positively correlated with %stage rapid eye movement (REM) sleep.

Conclusions: More than 50% of the participants had NSS. MH decreased during sleep, and change in MH was positively correlated with reduced %REM sleep due to OSAS. These results suggest that MH should be evaluated in patients undergoing assessment of OSAS.

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KEYWORDS: muscle hardness (MH) tester, neck-shoulder stiffness (NSS), sleep apnea syndrome (SAS), trapezius muscle

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Neck-shoulder stiffness (NSS) is a common complication of obstructive sleep apnea syndrome (OSAS). Although the term NSS is frequently used in Japan, there is no clear definition of the condition. Iijima et al. reported that NSS was defined in a survey in Japan and the United States as "stiffness, tension, pressure, or pain in the area of the upper back and neck".[1] Epidemiologically, the prevalence among Japanese was higher in females (13.1%) than in males (6.0%) in a survey by the Ministry of Health, Labour and Welfare in 2010.[2] Reports indicate that the subjective severity of NSS reduces quality of life (QOL).[3,4]

The pathogenesis of NSS is poorly understood. During NSS onset, the trapezius muscle (TM)—which attaches to a wide area from the back of the head to the neck, spinous processes of the thoracic vertebrae, and scapulae—has a critical role. The TM has a number of venous returns on the dorsal side, which have a tendency to clog because of the absence of venous valves.[5] This is the main reason for the development of symptoms. One report found that changes in local tissue circulation, such as a reduction in the muscle aerobic capacity of the TM, have an adverse effect.[6] Recently, TM muscle hardness (MH) has been used as a simple, objective measure of NSS and tension-type headache.[7–10]

Sleep deprivation was observed in 42.2% of patients with NSS symptoms, even when analgesics were given.[11] Moreover, the risk of NSS was higher when sleep disturbance was present.[12] The reasons for this association are unclear. To our knowledge, no study has investigated the relationship between OSAS and NSS. Loss of postural muscle tone during rapid eye movement (REM) sleep[13] may be associated with improvement in NSS and MH. However, OSAS causes sleep disturbance and shortens deep sleep and REM sleep.[14]

In this prospective study, we investigated the relationship of OSAS with NSS, MH, and polysomnography (PSG) data.

Methods

The subjects were 100 patients who visited the Department of Respiratory Medicine, Toho University Omori Medical Center or the Komagamine Sleep Respiratory Center and underwent PSG for assessment of OSAS. NSS was defined as the intensity of moderate or more severe symptoms, according to the criteria of Iijima et al,[1] and was evaluated before PSG. On the day participants underwent PSG, they were interviewed regarding whether they had NSS that adversely affected their daily lives. The TDM-NA1 device (Try-All Corp., Chiba, Japan) was used to measure MH. OSAS was defined as an apnea hypopnea index (AHI) of 5 or more events per hour under polysomnography, with an AHI of 20 events per hour as the cut-off point. All participants were Japanese with no history of cervical spine disease, severe physical impairment due to traffic accident, thoracic outlet syndrome, or surgery involving the area around the shoulders. All eligible patients were enrolled consecutively. The study was approved by the Toho University Omori Medical Center Ethics Committee, and informed consent was obtained from all patients (October 22, 2012, number 24–128).

Muscle hardness meter

The muscle hardness meter (TDM-NA1) was a simple, relatively broad durometer.[15] The upper grip is slowly pressed against a spring until a buzzer rings, after which the probe is released. The MH value is shown on the meter.

The same technician performed the measurements for all patients, before and after attachment of the PSG device. Participants faced forward while sitting on a chair without an armrest. They were asked to maintain a relaxed posture that would keep the proper physiological anterior curvature of the lumbar spine during measurement. With the midpoint of the acromion and the seventh cervical vertebra as the target, the MH of the TM above the shoulders was measured twice on each side. The mean of each side was recorded and analyzed.

Polysomnography

Standard overnight polysomnography was performed by continuous polygraphic recording of electroencephalography, electrooculography, submental electromyography, and electrocardiography from surface leads. Additional data collected were oronasal airflow signals from a nasal pressure sensor, respiratory effort signals from thoracic and abdominal impedance belts, oxyhemoglobin level from pulse oximetry, snoring characteristics from a tracheal microphone, and body position changes during sleep. Polysomnography records were scored manually according to standard criteria.[16,17]

Statistical Analysis

All data are presented as mean ± SD. Statistical differences among the groups were analyzed using the paired t test, nonpaired t test, and χ^2 test. We used Pearson correlation analysis to evaluate the univariate relationship between two variables. All statistical analyses were per-

Table 1 Participant characteristics (n = 100)

Demographic variables		
Sex (Male)	(n, %)	81 (81)
Age	(yr)	48.5 ± 14.5
Anthropometric variables		
BMI	(kg/m^2)	25.5 ± 5.3
Neck	(cm)	37.6 ± 3.8
Polysomnographic variables		
OSAS (AHI ≥5)	(n, %)	70 (70)
AHI	(/hr)	23.3 ± 24.4
3%ODI	(/hr)	21.1 ± 23.6
CT90	(%)	2.1 ± 5.0
Mean SpO_2	(%)	95.8 ± 2.0
Lowest SpO_2	(%)	80.2 ± 19.0
ArI	(/hr)	33.7 ± 20.1
%stage 1	(%)	24.8 ± 14.9
%stage 2	(%)	43.4 ± 11.2
%stage 3 + 4	(%)	11.9 ± 7.6
%stage REM	(%)	19.8 ± 6.3
Muscle variables		
NSS	(n, %)	53 (53)
Dominant hand (rt)	(n, %)	95 (95)

Values are mean ± SD.
BMI: body mass index, OSAS: obstructive sleep apnea syndrome, AHI: apnea hypopnea index, ArI: arousal index, ODI: oxygen desaturation index, CT90: cumulative time spent below a saturation of 90%, REM: rapid eye movement, NSS: neck-shoulder stiffness, rt: right

formed on a personal computer with a statistical software package (Windows, version 11.0; SPSS Japan Inc., Tokyo, Japan). A p value of less than 0.05 was considered to indicate statistical significance.

Results

Participant characteristics

Table 1 shows the characteristics of the 100 participants. There were 81 men and 19 women. The average age was 48.5 ± 14.5 years, and mean body mass index (BMI) was 25.5 ± 5.3 kg/m^2. Mean AHI was 23.3 ± 24.4 events per hour, and 70 patients had OSAS (70%). NSS was noted in 53 patients (53%), and most participants were right-handed (95%).

NSS and change in MH

As compared with values before PSG, MH was significantly lower on both sides after PSG (Fig. 1). Table 2 shows a comparison of the characteristics of participants with and without NSS. Although there was no significant difference in patient characteristics or OSAS severity between groups, the MH of the right TM before PSG and %stage REM sleep were significantly higher in participants with NSS.

OSAS and MH

Table 3 shows a comparison between patients classified by AHI, with an AHI of 20 events per hour as the cut-off point. As compared with patients with an AHI lower than 20, those with an AHI of 20 or higher had a significantly smaller reduction in MH on both sides, and significantly

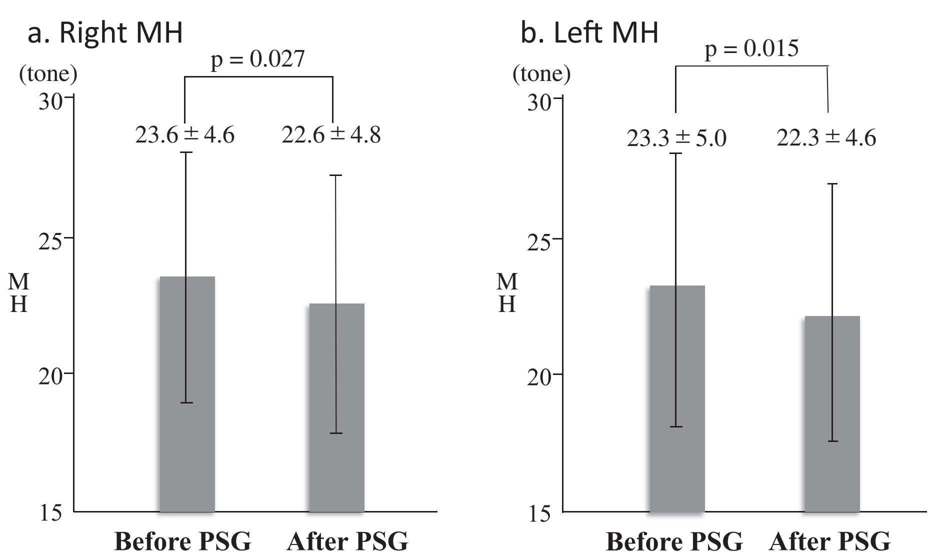

Fig. 1 Muscle hardness (MH) before and after polysomnography (PSG)
MH was significantly lower on both sides after PSG.

Table 2 Demographic, polysomnographic, and muscle characteristics of patients with and without NSS

			NSS (n = 53)	No NSS (n = 47)	p value
Sex (Male)		(n, %)	42 (79)	39 (83)	NS
Age		(yr)	46.0 ± 13.6	51.4 ± 15.1	NS
BMI		(kg/m^2)	26.2 ± 6.2	24.8 ± 3.8	NS
Neck		(cm)	37.9 ± 3.8	37.2 ± 3.6	NS
OSAS		(n, %)	35 (66)	35 (74)	NS
AHI		(/hr)	20.9 ± 23.6	25.9 ± 25.1	NS
ArI		(/hr)	31.2 ± 19.1	36.6 ± 21.0	NS
3%ODI		(/hr)	18.6 ± 22.9	24.0 ± 24.2	NS
CT90		(%)	1.9 ± 3.9	2.4 ± 6.1	NS
Mean SpO_2		(%)	95.9 ± 2.0	95.7 ± 2.0	NS
Lowest SpO_2		(%)	82.1 ± 15.7	78.2 ± 22.1	NS
%stage 1		(%)	22.2 ± 14.1	27.9 ± 15.4	NS
%stage 2		(%)	43.6 ± 11.1	43.2 ± 11.5	NS
%stage 3 + 4		(%)	12.8 ± 7.7	10.9 ± 7.5	NS
%stage REM		(%)	21.4 ± 6.0	18.1 ± 6.2	0.008
Right-handed		(n, %)	51 (96)	44 (96)	NS
Rt	Pre MH	(tone)	24.5 ± 5.1	22.5 ± 3.7	0.035
	Post MH	(tone)	23.3 ± 5.2	21.9 ± 4.2	NS
	Pre-Post MH	(tone)	1.2 ± 4.3	0.6 ± 4.1	NS
Lt	Pre MH	(tone)	23.7 ± 5.5	22.8 ± 4.2	NS
	Post MH	(tone)	22.4 ± 5.2	22.1 ± 3.9	NS
	Pre-Post MH	(tone)	1.2 ± 4.3	0.6 ± 3.4	NS

NSS: neck-shoulder stiffness, BMI: body mass index, OSAS: obstructive sleep apnea syndrome, AHI: apnea hypopnea index, ArI: arousal index, ODI: oxygen desaturation index, CT90: cumulative time spent below a saturation of 90%, REM: rapid eye movement, MH: muscle hardness, Rt: right, Lt: left, NS: not significant

greater MH on the left side, after PSG.

Muscle hardness and PSG

Table 4 shows factors associated with change in MH after PSG. Correlation analysis revealed that change in MH (ΔMH) on the right side had a weak inverse correlation with AHI, arousal index , 3% oxygen desaturation index (ODI), and %stage 1 sleep and a weak positive correlation with %stage REM sleep ($r = 0.296$ and $p = 0.003$). Change in MH on the left side had a weak inverse correlation with age, arousal index, and %stage 1 sleep and a weak positive correlation with %stage REM sleep ($r = 0.211$ and $p = 0.035$).

In stepwise linear multiple regression analysis, %stage REM sleep was the only variable significantly correlated with right ΔMH ($r^2 = 0.087$, $\beta = 0.296$, $p = 0.003$). Age was significantly correlated with left ΔMH ($r^2 = 0.081$, $\beta = -0.285$, $p = 0.004$).

Discussion

This is the first study to use PSG data to examine the associations of OSAS with NSS and the MH of the TM. More than 50% of the participants in this study had NSS, which suggests that patients should be evaluated for NSS during assessment of OSAS. The prevalence of NSS was slightly higher in a previous report.[4] However, because the present participants were suspected of having OSAS, a large proportion of middle-aged men were included, and the population was thus different from that of the earlier study. Therefore, a direct comparison is difficult.

Sleep alleviates muscle tension, but no report has measured MH before and after sleep to investigate change in MH. In our study, change in MH was assessed by measurements at the same site under identical conditions, which should make measurement more reliable. In previ-

Table 3 Demographic, polysomnographic, and muscle characteristics of patients with AHI >20 and ≤20

			AHI <20 (n = 55)	AHI ≥20 (n = 45)	p value
Sex (Male)		(n, %)	46 (84)	39 (83)	NS
Age		(yr)	45.0 ± 14.4	52.8 ± 13.5	NS
BMI		(kg/m^2)	24.6 ± 5.4	26.6 ± 5.0	NS
Neck		(cm)	37.4 ± 3.6	37.8 ± 3.9	NS
AHI		(/hr)	5.9 ± 6.1	44.5 ± 21.2	<0.001
ArI		(/hr)	21.5 ± 8.8	48.7 ± 19.8	<0.001
3%ODI		(/hr)	5.1 ± 5.4	40.7 ± 22.3	<0.001
CT90		(%)	0.0 ± 0.1	4.7 ± 6.7	<0.001
Mean SpO_2		(%)	96.8 ± 1.0	94.7 ± 2.4	NS
Lowest SpO_2		(%)	82.9 ± 23.8	76.9 ± 9.6	<0.001
%stage 1		(%)	16.9 ± 7.3	34.6 ± 16.0	<0.001
%stage 2		(%)	47.9 ± 9.9	38.0 ± 10.4	<0.001
%stage 3 + 4		(%)	13.1 ± 6.6	10.4 ± 8.6	NS
%stage REM		(%)	22.2 ± 5.4	17.0 ± 6.2	<0.001
Right-handed		(n, %)	50 (93)	45 (100)	NS
NSS		(n, %)	32 (58)	21 (47)	NS
Rt	Pre MH	(tone)	23.7 ± 4.8	23.4 ± 4.2	NS
	Post MH	(tone)	22.0 ± 4.7	23.4 ± 4.8	NS
	Pre-Post MH	(tone)	1.7 ± 4.7	− 0.1 ± 3.8	0.034
Lt	Pre MH	(tone)	22.9 ± 5.1	23.7 ± 4.8	NS
	Post MH	(tone)	21.2 ± 4.6	23.6 ± 4.4	0.007
	Pre-Post MH	(tone)	1.8 ± 4.4	0.1 ± 3.5	0.039

AHI: apnea hypopnea index, BMI: body mass index, ArI: arousal index, ODI: oxygen desaturation index, CT90: cumulative time spent below a saturation of 90%, REM: rapid eye movement, NSS: neck-shoulder stiffness, Rt: right, Lt: left, NS: not significant

ous studies, MH was measured before and after a variety of interventions, such as yoga,[18] magnetic stimulation,[19] and a massage chair,[20] after which improvement was evaluated. Therefore, the present method of evaluating MH before and after PSG is reasonable.

There was no increase in OSAS severity among participants with NSS. Nevertheless, a number of factors are associated with NSS, including female gender, work at a visual display terminal, amount of sedentary time during work, fatigue, stress, decreased physical activity, decreased sleep quality, depression, and anxiety.[3,21–23] Because of the complicated nature of these factors, the influence of OSAS on NSS might not be readily apparent.

We found that OSAS patients with an AHI of 20 or more events per hour had greater MH after sleep and a smaller change after sleep. The cut-off point for AHI used in this study was selected because it was close to the mean AHI of the participants and is regarded as the clinical threshold for Japanese national health insurance coverage of nasal continuous positive airway pressure therapy. REM sleep is a factor involved in the association of sleep with NSS and MH. During sleep, the reticulospinal tract induces postsynaptic suppression in motor cells via the locus coeruleus and raphe nuclei of the pons in the brain stem to the reticular nucleus of the medulla and suppresses the tonus of skeletal muscles throughout the body.[24,25] Interestingly, disappearance of muscle activity in antigravity muscles and skeletal muscles throughout the body is important in improving NSS and reducing MH, particularly during REM sleep. This indicates that it might be useful to determine whether nasal continuous positive airway pressure therapy increases REM sleep[26] and increases the reduction in MH during sleep in patients with OSAS.

It is unclear why, among participants with NSS, %stage REM sleep was significantly higher and why age was inversely correlated with change in MH. Further investiga-

Table 4 Associations of MH after PSG (ΔMH) with demographic and polysomnographic characteristics

	Rt ΔMH		Lt ΔMH	
	r	p value	r	p value
Age	0.965	NS	−0.285	0.004
BMI	0.491	NS	−0.137	NS
Neck	0.295	NS	−0.046	NS
Waist	0.933	NS	−0.108	NS
AHI	−0.205	0.041	−0.180	NS
ArI	−0.283	0.004	−0.212	0.035
3%ODI	−0.201	0.045	−0.179	NS
CT90	−0.159	NS	−0.084	NS
Mean SpO_2	0.103	NS	0.076	NS
Lowest SpO_2	0.006	NS	0.117	NS
%stage 1	−0.279	0.005	−0.248	0.013
%stage 2	0.046	NS	0.125	NS
%stage 3+4	0.234	0.019	0.125	NS
%stage REM	0.296	0.003	0.211	0.035

MH: muscle hardness, PSG: polysomnography, Rt: right, Lt: left, BMI: body mass index, AHI: apnea hypopnea index, ArI: arousal index, ODI: oxygen desaturation index, CT90: cumulative time spent below a saturation of 90%, REM: rapid eye movement, NS: not significant

tion is thus warranted. The fact that REM sleep decreases with age[27] may be relevant to these findings.

Most of the present participants were right-handed, which is a causal factor in the difference in MH change between the right and left sides. The amount of muscle is greater in the dominant upper limb than in the nondominant upper limb,[28] and the amount of activity in the TM during computer work is significantly greater on the side of the dominant hand.[29] Taken together, these findings likely explain the laterality of our results.

This study had limitations, the most important of which is the presence of bias in the subject population. Because OSAS is more frequent in men,[30] and only 19% of the participants were women, it was impossible to investigate sex differences in the associations of interest. Kimura et al. reported that shoulder stiffness was more severe on both sides in women than in men and that significantly more women than men complained of symptoms.[3] A survey by the Ministry of Health, Labor and Welfare yielded similar results.[2] NSS is generally more prevalent among women; thus, sex differences should be investigated. Second, NSS has been attributed to a variety of causes,[31] but the cause of NSS was not investigated in detail in this study. Third, although the MH tester used in this study was equipped with a function to maintain constant pressure,[32] intra-vserver variability in measuring MH is a concern.

Conclusion

Patients who underwent PSG for investigation of OSAS often complained of NSS, and those with NSS had greater MH in the right TM. MH decreased significantly after sleep, and the change was positively correlated with the reduction in %REM sleep caused by OSAS. These results suggest that it is necessary to assess NSS in patients being evaluated for OSAS.

The TDM-NA1 muscle hardness meter was rented from the TRY-ALL corporation.

Conflicts of interest: None declared.

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閉塞性睡眠時無呼吸症候群と僧帽筋の筋硬度との関連性

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要約

目的：肩こりとは肩部の筋緊張を中心とするさまざまな症状を指し，疫学的に頻度が高く quality of life への影響がある．睡眠時無呼吸症候群（obstructive sleep apnea syndrome：OSAS）と肩こりおよび筋硬度との関連性を検討した．

対象および方法：OSAS 精査目的で終夜睡眠ポリグラフ（polysomnography：PSG）検査を行った 100 名を対象とした．それぞれの患者に PSG 検査前後に筋硬度計を用いて左右の僧帽筋肩上部の筋硬度を測定し，肩こりや PSG 検査データとの関連性を検討した．

結果：肩こりは 53% にみられた．PSG 前に比較して PSG 後の筋硬度は，左右ともに有意な低下を認めた．肩こり＋群は肩こり－群に比較して，PSG 検査前の右筋硬度において有意に高値であった．無呼吸低呼吸指数（apnea hypopnea index：AHI）≥20 の群は AHI＜20 の群と比較して，両側の PSG 前後の筋硬度の低下量が有意に減少しており，PSG 後の左筋硬度は有意に高値であった．筋硬度の PSG 前後の変化量とは，右の筋硬度の変化量と AHI，%stage 1 に弱い負の相関を認め，%rapid eye movement（%REM）に弱い正の相関が認められた．

結論：OSAS に対する肩こりの合併頻度は半数以上であった．筋硬度は睡眠により低下し，またその変化量は REM 睡眠との関連性が認められた．OSAS 診療において筋硬度を評価する必要性が示唆された．

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