Original Article

A comparative study of L 1 and Qigong manoeuvres

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The relative efficacy of L 1 and Qigong [QG] manoeuvres was studied. 27 aircrew participated in this study, which was conducted on the human centrifuge at IAM, using standard GOR profiles. Mean gain in G tolerance was 2.9 G [SD ± 0.56] for L 1 manoeuvre, and 2.5 G [SD ± 0.51] for QG manoeuvre. The difference was statistically significant [$p < 0.05$]. This paper describes the mechanisms of the two AGSMs, highlighting their differences and giving possible explanations for the same.

Keywords: AGSM, G tolerance, aircrew indoctrination.

There are different anti G straining manoeuvre (AGSM) methodologies available for providing protection against G stress. L 1 is the universally accepted AGSM, and has been in use for several decades [1]. It is being taught to aircrew during centrifuge training at the Institute of Aerospace Medicine Indian Air Force Bangalore (IAM) [2].

A new AGSM has been developed at the Institute of Aviation Medicine, Beijing in 1987 [3]. It is known as the Qigong [QG] manoeuvre, based on the science of Qigong, which incorporates meditation and breathing exercises [4].

To compare the effectiveness of the two types of AGSMs, a study was conducted at IAM, in 1995.

Material and methods

Twenty seven fighter aircrew who reported to IAM for Combined Aircrew Indoctrination Course [CAIC], participated in the study. All the subjects were currently flying MiG type of aircraft. Their total flying hours varied from 360 to 2280 hours with a mean of 729.3 hours (SD ± 410.68). The age of the subjects ranged from 23 to 35 years with mean of 26.1 years (SD ± 2.42). Their height ranged from 164 to 180 cm with mean of 172.9 cm (SD ± 4.98). Their weight ranged from 50 to 88 kg with mean of 66.07 kg (SD ± 8.45).

The subjects were taught the two types of AGSMs in the following manner:

L 1 manoeuvre: The subject was asked to sit on a chair. He then tensed up all the muscles. Simultaneously he was asked to have a quick inhalation followed by straining against a closed glottis for 3 sec, and then forceful exhalation. His efforts were coordinated by calling out: Now-1-2-3-4, over a total period of 4 sec.

QG manoeuvre: The subject was seated on a chair and instructed to keep his body in readiness for the exercise to be followed. The subject was then told to rest his feet on his heels and raise his instep first and then tread on the ground forcefully with the heels. The abdominal muscles were also contracted voluntarily. At the same time, breath was held transiently, followed by forceful, rapid, shallow thoracic respiration at the rate of about 60/min. This was continued for 60 sec.

Centrifuge runs: All the subjects were first trained on ground and then given practice to perform the AGSMs during Rapid Onset Runs (ROR), at G levels of 4, 5 and 6 G. Thereafter the efficacy of the particular AGSM was assessed on a Gradual Onset Run (GOR). By determining the relaxed and straining tolerance levels and thereby deducing the protection afforded by the AGSM. All the runs were conducted between 0800 h and 1200 h to preclude

any variation in tolerance due to circadian rhythm.

a) ROR profiles : Onset rate 1 G/sec
Peak 4 G for 15 sec/5 and 6 G for 30 sec
Offset rate –0.5 G/sec up to 2 G, level off at 2 G for 4 sec then –0.2 G/sec.

b) GOR profile: Onset rate 0.1 G/s
Peak 9 G for 2 sec
Offset rate –1 G/sec up to 2 G, level off at 2 G for 4 sec –0.2 G/sec, then

A questionnaire was given to each subject for subjective evaluation of the AGSMs performed.

Statistical analysis

The gain in G tolerance by performance of the different techniques of AGSM was determined and compared, paired t test was used for determining the statistical significance.

Table 1. LI Manoeuvre

Subject No	Relaxed Tolerance (Rel) G	Straining Tolerance (Str) G	End Point Reached	Gain in Tolerance (Str-Rel) G
1	4.5	7.6	YES	3.1
2	4.9	8.0	YES	3.1
3	3.5	6.0	YES	2.5
4	4.3	7.4	YES	3.1
5	5.7	8.0	YES	2.3
6	4.3	7.4	YES	3.1
7	4.2	8.3	YES	4.1
8	5.7	8.6	YES	2.9
9	5.1	7.9	YES	.8
10	5.9	8.4	YES	2.5
11	5.7	8.9	YES	3.2
12	5.4	8.0	YES	2.6
13	5.9	8.4	YES	2.5
14	4.7	7.2	YES	2.5
15	5.5	8.2	YES	2.7
16	4.5	7.8	YES	3.3
17	6.5	8.9	YES	2.4
18	4.3	7.3	YES	3.0
19	6.3	9.0	YES	2.7
20	5.3	6.7	YES	1.4
21	6.7	9.0	no grey out	2.3
22	6.1	9.0	no grey out	2.9
23	5.9	8.8	YES	2.9
24	5.2	9.0	YES	3.8
25	5.1	9.0	YES	3.9
26	5.4	9.0	YES	3.6
27	5.9	9.0	no grey out	3.1
Mean ± SD				2.90 0.56

Table 2. Gain in G tolerance QG manoeuvre

Subject No	Relaxed Tolerance(Rep)	Straining Tolerance(Str)	End Point Reached	Gain in Tolerance (Str-Rep)
	G	G		G
1	4.6	7.4	YES	2.8
2	4.9	6.8	YES	1.9
3	3.0	5.9	YES	2.9
4	4.7	7.6	YES	2.9
5	5.0	6.9	YES	1.9
6	4.4	6.4	YES	2.0
7	4.2	7.0	YES	2.8
8	5.5	7.9	YES	2.4
9	4.0	5.8	YES	1.8
10	4.9	6.9	YES	2.0
11	5.5	7.9	YES	2.4
12	5.1	6.7	YES	1.6
13	4.4	6.5	YES	2.1
14	4.7	7.1	YES	2.4
15	5.0	8.0	YES	3.0
16	4.3	7.1	YES	2.8
17	6.1	8.9	YES	2.8
18	4.5	6.7	YES	2.2
19	5.9	8.5	YES	2.6
20	5.4	9.0	YES	3.6
21	6.5	9.0	no grey out	2.5
22	6.1	9.0	no grey out	2.9
23	6.6	9.0	no grey out	2.4
24	6.3	9.0	no grey out	2.7
25	5.4	9.0	no grey out	3.6
26	5.5	7.4	YES	1.9
27	6.5	9.0	no grey out	2.5
Mean ± SD				2.80 0.51

Subjective Feed back

Name: Serial No:

Instruction: Answer the following with 'Yes' or 'No' [put a tick mark]:

	L_1		QG	
	Yes	No	Yes	No
Is the particular AGSM efficient?				
Is the particular AGSM fatiguing?				
Is it difficult to give RT calls during ACSM?				
Which AGSM technique do you prefer				

Result

The gain in G tolerance was obtained by the difference of straining and relaxed tolerance. For the L 1 manoeuvre the gain in G tolerance ranged from 1.4 to 4.1 G, with a mean of 2.9 G (SD ± 0.56_. Three subjects did not have grey out while performing the AGSM (Table 1). For QG manoeuvre the gain in G tolerance ranged from 1.6 to 3.6 G, with a mean of 2.5 G (SD ± 0.51). Five subjects did not have grey out while performing the AGSM (Table 2).

Table 3. Aircrew Subjective Feedback

A) Overall Efficiency				
Yes	26	96%	16	59%
No	1	4%	11	41%
B) Fatiguing				
Yes	29	74%	2	7%
No	7	26%	25	93%
C) Difficulty in giving RT calls				
Yes	23	85%	0	–
No	4	15%	–	–
D) Acceptability	18	33%	9	67%

The results of the subjective assessment were as follows (Table 3):

a) Efficiency: 26 (96%) subjects found L 1 manoeuvre to be efficient, while 16 (59%) subjects found QG manoeuvre to be efficient.

b) Fatigue: 20 (74%) subjects found L 1 manoeuvre to be fatiguing, while 2 (7%) subjects found QG manoeuvre to be fatiguing.

c) Difficulty level in giving RT calls: 23 (85%) subjects found difficulty in giving RT calls during L 1 manoeuvre, while none of the subjects found difficulty in giving RT calls during QG manoeuvre.

d) AGSM of choice: Majority of the subjects 18 (67%) found QG manoeuvre as the AGSM of choice, only 9 (33%) subjects found L 1 manoeuvre to be the more acceptable AGSM.

Discussion

Pilots of modern combat aircraft must tolerate +Gz forces of high magnitude for a considerable period of time. The relaxed rapid onset rate (ROR) G tolerance of a fighter pilot is about 4.17 G [5]. Since pilots are expected to fly high performance aircraft with 9 G capability, G tolerance of the pilots must be increased. AGSM has been found to be an effective method of increasing G tolerance.

L 1 manoeuvre has two main components, *viz*, muscle straining and vigorous breathing performed simultaneously. QG manoeuvre follows a different concept of straining and breathing. In addition, an element of mental concentration is required to coordinate the different components of the manoeuvre. Guo *et al* [6] stated that systolic blood pressure could be raised by 30 mm Hg in a relaxed individual, by practising Qigong.

Any form of AGSM requires good muscular strength and coordination [7]. This is particularly true for the QG manoeuvre. In this manoeuvre, the lower limb and abdominal muscles play a crucial role in prevention of pooling of blood during G stress. The respiratory component is important for maintaining the arterial pressure at the brain level. This is achieved, as there is no sharp fluctuation in intrathoracic pressure (ITP) [8]. On the other hand, in L 1 manoeuvre, the vigorous respiratory process helps in increasing the ITP during the expiratory phase, with subsequent drop in ITP during inspiration. Therefore, in QG manoeuvre, a coordinated and effective lower limb and abdominal muscle contraction is most essential for providing optimal G protection.

Guo *et al* [3] has stated that, the muscle straining component is more important than respiratory component in raising SBP.

In the present study, an attempt has been made to compare the effectiveness of L 1 and QG manoeuvres.

The gain in G tolerance as obtained by performance of L 1 manoeuvre was found to be 2.9 G (SD ± 0.56). Three subjects did not have grey out during the assessment of AGSM. The gain in G tolerance determined by the present study was similar to that found by Gomez *et al* [5], who found the gain in G tolerance in 134 Indian aircrew to be 2.8 G, and Kapur *et al* [9], who determined the gain in G tolerance in 28 pilots to be 3.18 G (SD ± 0.51).

The mean gain in G tolerance of 27 subjects, while performing QG manoeuvre was found to be 2.5 G (SD ± 0.51). Five subjects did not have grey out during assessment of AGSM.

Zhang *et al* [10] found the gain in ROR straining tolerance with QG manoeuvre and without Anti G suit in 18 subjects as 2.82 G (SD ± 0.7), and with Anti G suit as 3.95 G (SD ± 0.60). ROR tolerance utilising QG manoeuvre was not determined in the present study. Therefore, the results could not be compared with that of Zhang *et al*. Due to paucity of any other work done on QG manoeuvre, no comparison of the results obtained could be made.

The difference in the gain in G tolerance, as obtained by the performance of L 1 and QG manoeuvres was found to be significant ($p < 0.05$). There are two reasons for the difference. Firstly the subjects had a greater exposure to L 1 manoeuvre, while completing the curriculum of the centrifuge training course, and a large number of centrifuge runs were dedicated to perfecting this AGSM technique. In the case of QG manoeuvre, the subjects practised the manoeuvre on ground, and were given only a few exposures on the centrifuge. Secondly, the training imparted to the subjects in the present study might not be as efficient as that followed in the study conducted by Zhang *et al*. This was due to lack of experience of the authors and subjects in the science of Qigong. The Chinese subjects were given extensive coaching in Qigong, which included meditation, in a sanitarium for a duration of two weeks by experienced tutors. In the present study, meditative techniques were not imparted. Emphasis was given only on the performance of QG manoeuvre, in which the subjects were taught sequential muscle tensing and breathing manoeuvres over a period of 3 days. Since meditation forms a very important component of QG manoeuvre, there is a scope for further increasing the gain in G tolerance by proper training in the science of Qigong.

A number of subjects did not have grey out during the assessment of AGSM. Three of them did not have grey out during L 1 and five during QG manoeuvre. If the limitation on the centrifuge run was removed, the gain in GOR tolerance would have been much greater, and the true gain in G tolerance could then be assessed. This would have led to a more proper comparison in the gains, obtained by the two AGSMs.

The subjects gave their unbiased opinion on factors of efficiency, fatigue during performance, difficulty level in giving RT calls, and overall preference of AGSM technique.

Efficiency: L 1 manoeuvre was considered by the majority of subjects (96%) to be most efficient while (59%) found the QG manoeuvre to be efficient. As the subjective assessment of the AGSMs for efficiency was likely to be dependent on the individual performance in the centrifuge using a particular AGSM, L 1 was considered to be the most efficient as this is the main AGSM taught during the course.

Fatigue: L 1 manoeuvre was found to be more fatiguing by majority of the subjects (74%). However only 7% found the QG manoeuvre to be fatiguing. This finding was similar to that obtained by Zhang *et al* [8].

RT calls: 84% of the subjects felt that L 1 manoeuvre led to difficulty in verbal communication, while none of the subjects felt any difficulty in verbal communication during performance of QG manoeuvre. This fact bears important connotations, as RT communication is done quite frequently during combat. An AGSM technique which does not interfere with RT communication is therefore highly desirable.

Acceptability: Out of the two AGSMs, QG was the more preferred AGSM (67%). The greater preference for QG could be explained by the fact that QG is less tiring, and there is no interference in communication on the RT. Zhang *et al* stated that the simple and orderly fashion of execution of QG manoeuvre made it the AGSM of choice of pilots of Chinese Air force [10].

Conclusion

In the present study, comparison of L 1 and QG manoeuvres was carried out. L 1 was found to provide significantly higher G tolerance as compared to QG manoeuvre. However, the true

gain in G tolerance could not be determined in some subjects, as the end point could not be reached due to limitations set on the centrifuge profile. Subjectively, QG was preferred to I. I manoeuvre, in spite of the lesser protection provided. It is suggested that further studies need to be carried out for the evaluation of QG manoeuvre, after proper training of subjects in the science of Qigong.

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