





nostril breathing to be checked, as these practices can be carried on effortlessly for prolonged periods.

In the present study the effects of these yoga breathing practices on hand grip were considered worth investigating based on the above mentioned facts as well as two more, viz., [i] unilateral forced nostril breathing has been reported to cause contralateral cerebral hemisphere stimulation (4), and [ii] it was shown (5) that difference in hand grip between the two hands are related to the relative functioning of the two cerebral hemispheres.

Hence the present study was designed to compare the effects of ten days of each of four yoga breathing practices, i.e. selective right nostril breathing, selective left nostril breathing, alternate nostril breathing, breath awareness without nostril manipulation, on the hand grip of both hands separately. It was aimed at finding out whether there was any lateralization effect (e.g. with right nostril breathing, right hand grip changes or whether a contralateral effect is observed). There was a fifth group which practiced certain hand gestures (mudras). This was considered necessary as the pranayama practice in specific yoga exercises, i.e. sav, cav, and nds groups is associated with specific mudras. These practices involve keeping the fingers in specific postures, which could possibly influence hand grip strength.

## METHODS

*Subjects* : The subjects were 130 school children of 11 and 18 years of age. They attended a 10 day residential yoga training camp during the school vacation. The children were all from a similar social and

academic background. For all the subjects the right hand was dominant.

*Design* : The hand grip of both hands was assessed in all subjects, in the same manner. The subjects were then randomly assigned to five groups. All five groups had the same basic yoga training. In addition each of the five groups practiced a specific yoga exercise, viz., [i] sav, surya anuloma viloma pranayama or right nostril breathing, [ii] cav, chandra anuloma viloma pranayama or left nostril breathing, [iii] nds, nadisuddhi or alternate nostril breathing, [iv] baw or breath awareness without nostril manipulation, since breath awareness is a part of the first three practices, and [v] mdr with specific mudras. The first four groups had 30 subjects each, while the fifth group had 10 subjects. The group average age (in years)  $\pm$  SD for the five groups was as follows: sav -  $14.1 \pm 1.2$ , cav -  $14.0 \pm 1.1$ , nds  $13.9 \pm 1.2$ , baw -  $14.9 \pm 1.8$ , and mdr -  $14.4 \pm 2.6$ . The assessments were made at the beginning and end of the 10 day camp.

*Assessment procedure* : Hand grip strength was assessed using a grip dynamometer (Anand Agencies, Pune, India). Subjects were tested in 6 trials, 3 for each hand alternately with 10 seconds gap between trials. During the assessment subjects were asked to keep their arm extended at shoulder level, horizontal to the ground as has been described earlier (6). The maximum value obtained during the three trials was used for analysis.

*Yoga training* : The subjects of all five groups practiced asanas, pranayama practices (excluding the group-specific practices), meditation, lectures, and kriyas. Each of the specific practices have been described in detail elsewhere (7), and are



mentioned briefly here. All five practices involved sitting cross legged with eyes closed. (i) Surya anuloma viloma pranayama (sav) involves inhalation and exhalation through the right nostril alone. (ii) Chandra anuloma viloma pranayama (cav) involves inhalation and exhalation through the left nostril alone. (iii) Nadisuddhi pranayama (nds) begins with exhalation (both nostrils) followed by inhalation through the left, then exhalation through the right nostril, inhalation again through the right, and exhalation through the left nostril, to complete the round. These specific pranayamas were practiced as 27 rounds, four times a day. All 3 practices were accompanied by the practice of specific mudras or hand gestures. These have been

and index finger in contact and other fingers extended.

*Data analysis* : The data obtained for each of the four groups at the beginning and end of the camp were compared with separate two tailed 't' - tests for paired data.

## RESULTS

*Right hand* - There were significant increases in hand grip scores in the nds, sav, cav groups. The t and corresponding P values were: t = 3.19, P<.005; t = 2.69, P<.05; and t = 2.95, P<.01, respectively.

*Left hand* - There were significant increases in hand grip scores in the nds, sav, and cav groups. The 't' and corresponding

TABLE I : Hand grip strength in kg in five groups at the start (S) and end (E) of the 10-day camp for right (RH) and left (LH) hands. Values are group mean  $\pm$  SEM.

		SAV	CAV	NDS	BAW	MDR
RH	S	25.6 $\pm$ 1.3	23.9 $\pm$ 1.0	24.0 $\pm$ 1.6	26.7 $\pm$ 1.4	29.5 $\pm$ 2.4
	E	26.7 $\pm$ 1.4*	24.9 $\pm$ 1.0**	26.4 $\pm$ 1.6***	27.1 $\pm$ 1.4	29.4 $\pm$ 2.2
LH	S	24.0 $\pm$ 1.3	22.3 $\pm$ 1.1	23.6 $\pm$ 1.7	25.1 $\pm$ 1.4	28.1 $\pm$ 2.2
	E	25.5 $\pm$ 1.3****	23.4 $\pm$ 0.9*	24.8 $\pm$ 1.5*	25.6 $\pm$ 1.4	28.2 $\pm$ 2.1

\*P<.05, \*\*P<.01, \*\*\*P<.005, \*\*\*\*P<.002, paired 't' test S versus E.

described under the fifth group. (iv) Breath awareness or baw, involved being aware of the breath without manipulating the nostrils. (v) Mudra or mdr involved keeping the fingers in specific positions. For example, the right hand was used to manipulate the nostrils. The index and middle fingers were flexed, while other fingers were extended and used to gently close the nostrils. The left nostril with the ring finger and the right nostril with the thumb. The left hand was kept resting on the left knee with the tips of the thumb

P values were: t = 2.13, P<.05; t = 2.13, P<.05; t = 3.45, P<.002; and t = 2.31, P<.05, respectively. Group mean values  $\pm$  SEM are provided in Table I.

## DISCUSSION

In the present study school children belonging to the alternate nostril breathing (nds), right nostril breathing (sav), and left nostril breathing (cav) groups showed a significant increase in the hand grip strength of both hands at the end of the



ten day yoga training camp. The breath awareness (baw) and hand gesture/mudra (mdr) groups showed no significant change. There was no clear lateralization effect, i.e. neither ipsilateral nor contralateral to the nostril of breathing. Both sav and cav groups showed a marginally greater increase in left hand scores compared to the right hand (6.5% versus 4.4% and 5.3% versus 4.1%, respectively for sav and cav groups). The nds group showed marginally greater scores for the right hand (6.3 versus 5.0%).

The absence of change in the mdr group suggests that practice of the mudras alone did not change the hand grip strength. Also, breath awareness alone did not produce any change. This suggests that the practice of pranayama has a significant effect in increasing hand grip strength, bilaterally, irrespective of (i) the nostril through which the subjects breathe. (ii) maintaining breath awareness, or (iii) the practice of mudras.

Previous studies have shown that twelve weeks practice of selected asanas (30 min a day) cause a 21 percent increase in the hand grip strength in normal volunteers (6). The practice of pranayama (48 min a day) in addition to physical workouts caused an increase in work rate on a treadmill and reduction in oxygen consumption per unit work, compared to a group which had physical workouts alone (8). Work did not increase blood lactate levels in the 'pranayama' group, which also had significantly lower values at rest. Hence the practice of pranayama made the significant difference, even though both groups were already doing physical workouts. This is similar to the results of the present study, in which the practice of pranayama four times a day in three groups (sav, cav, nds)

made a significant difference to hand grip scores, compared to two other groups (baw, mdr), even though all five groups practiced yogasanas, pranayama practices excluding the group-specific practices, kriyas, lectures and meditation. The availability of energy and oxidation of glucose is believed to influence the hand grip strength proportionately (9). Hence the pranayama practice may increase hand grip strength by reducing the oxygen requirement. The other important issue is whether *any* pranayama would cause the change, or whether the result was specific for sav, cav and nds practices. In the study cited above (8), the pranayama practice was not described. In the present study, since all five group practiced non-specific pranayamas and breathing techniques, i.e. sectional breathing, yoga breathing, nadisuddhi, brahmari, sitali, sitkari, sadanta and ujjayi, it appears as though the group specific practices (sav, cav, nds) made the difference. In the traditional texts pranayama practices involving manipulating the nostrils, are supposed to balance and awaken the life energy (10). This may be an explanation for the improved grip strength following sav, cav or nds. However, there is no scientific validation for this. It is also possible that the time spent in specific pranayama practices (27 rounds, four times a day), in addition to an hour a day for the non-specific practices (common to all five groups) was responsible, during the 10 day period. In the earlier cited study (8), subjects practiced pranayama for 48 minutes a day, but they were followed up after one and two years. In order to be able to decide whether the effect observed in the present study is related to the *duration* or *type* of pranayama practice further comparative studies are required.

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