



years of age, also showed improved hand grip strength following a yoga residential camp, which had yoga breathing, or *pranayama* (i.e., voluntarily regulated breathing) as the main practice (8). This improvement in hand grip strength following yoga, was also seen in patients in whom the function of gripping is abnormal due to disease. Patients with rheumatoid arthritis having pain and swelling of finger joints showed a trend of improvement in hand grip strength following a daily yoga session for 5 days a week, for 8 weeks, followed by weekly 2-hour sessions for a further 3 months (2). Hence the earlier studies, described above, investigated either selected subjects (e.g., adults with training in physical education), selected yoga practices (e.g., *pranayama*), or patients who were given daily sessions of yoga practice, rather than training in lifestyle change.

The present study aimed at assessing the effect of yoga training on grip strength in: (i) adults who had no special earlier physical training, (ii) children, following a ten day yoga camp without specific emphasis on any one practice, and (iii) patients with rheumatoid arthritis who were given an intensive yoga therapy practice, including suggestions for life style and mental attitude change.

## METHODS

### Subjects

There were 3 categories of subjects: (i) adults (n=37), (ii) children (n=86), and (iii) patients with rheumatoid arthritis (n=20), diagnosed based on standard clinical criteria. An equal number of adult volunteers (n=37), children (n=86), and

patients with rheumatoid arthritis (n=20), who did not practice yoga formed the respective control groups. Details (e.g., age range, number of subjects of each gender), are provided in Table I. Subjects were tested for hand dominance, by asking questions about which hand was used to comb the hair, throw a ball, or to write. Two left-hand dominant subjects were excluded from the study.

Both groups (yoga, control) of patients were allowed to continue medication which was prescribed for them. 10 out of 20 patients of the yoga group and 6 out of 20 patients of the control group were on NSAIDs (non-steroidal anti-inflammatory drugs) at the start of the study. The other patients were not receiving medication. The drug score was noted as number of NSAID tablets per day. This was noted every day. However, for analysis values on Day 1 and Day 14 were used.

### Design of the study

The three categories of subjects, viz., adults, children and patients with rheumatoid arthritis, received yoga for varying periods based on the yoga camp they were attending. For example, the duration of the yoga training camp was 1 month for adults (n=37), 10 days for children (n=86), and 14 days for rheumatoid arthritis patients (n=20). During these periods of yoga practice, an equal number of "control" subjects of comparable age and sex were studied at the beginning and end of a period during which they did not practice yoga, but carried on with their routine activities. Hence "control" group subjects were assessed as follows: adults (n=37), after

1 month, children (n=86) after 10 days, and patients (n=20) after 14 days.

#### Assessments

Hand grip strength of both hands was assessed using a hand grip dynamometer (Anand Agencies, Pune, India). Subjects were tested in 6 trials, 3 for each hand alternately, with a gap of 10 seconds 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 (3). The maximum value obtained during the three trials was used for statistical analysis.

#### Interventions

Certain yoga practices were taught common to all three categories of subjects (i.e. adults, children, and patients). These included yoga *asanas* or postures (60 minutes), *pranayama* or voluntarily regulated breathing, meditation, and lectures about yoga philosophy. However, as

part of the respective courses. other practices were specific for each of the three categories of subject, i.e., additional yoga postures for adults, memory games for children which involved chanting verses from ancient Indian texts, and joint loosening exercises for patients with rheumatoid arthritis.

#### Analysis

The before and after comparison of each category of subjects was analyzed for subjects of each gender separately, using the paired "t"-test (two-tailed).

## RESULTS

Subjects of all three categories (i.e., adult and child volunteers and adult patients with rheumatoid arthritis) showed significant increases in hand grip strength following yoga. The control group, who did not practice yoga showed no change. The group mean values  $\pm$  S.D. and percent

TABLE I: Details about subjects.

Sl. No	Category	Group	Gender	Number (n)	Age range (years)	Group mean age $\pm$ S.D. (years)
1	Adults (n=74)	Yoga	Male	21	22-50	31.0 $\pm$ 7.4
			Female	16	22-49	29.9 $\pm$ 7.1
		Control	Male	21	22-50	32.3 $\pm$ 6.7
			Female	16	20-40	26.4 $\pm$ 6.4
2	Children (n=172)	Yoga	Male	61	12-15	13.6 $\pm$ 1.0
			Female	25	12-15	13.5 $\pm$ 0.9
		Control	Male	61	12-15	13.7 $\pm$ 1.0
			Female	25	12-15	14.0 $\pm$ 0.8
3	Patients (n=40)	Yoga	Male	10	23-43	33.0 $\pm$ 7.7
			Female	10	26-43	35.0 $\pm$ 5.3
		Control	Male	10	21-42	31.7 $\pm$ 7.7
			Female	10	23-41	31.4 $\pm$ 5.5

TABLE II: Hand grip strength in adult volunteers, children, and adult patients of both groups (yoga and control), before and after yoga or the non yoga control period, respectively. Values are group mean  $\pm$  SD.

Category	Gender	Group	Hand	Before (kg)	After (kg)	%Change
Adults (n=74)	M n=21	YOGA	L	38.4 $\pm$ 4.7	43.1 $\pm$ 4.7**	12.4
			R	40.7 $\pm$ 4.5	45.5 $\pm$ 5.2***	11.6
	F n=16	YOGA	L	23.8 $\pm$ 6.3	30.3 $\pm$ 7.1***	27.3
			R	26.8 $\pm$ 7.0	23.3 $\pm$ 8.5***	24.3
	M n=21	CONTROL	L	37.9 $\pm$ 7.4	37.3 $\pm$ 7.6	-1.6
			R	39.7 $\pm$ 6.2	40.0 $\pm$ 6.4	0.6
	F n=16	CONTROL	L	20.3 $\pm$ 8.1	19.6 $\pm$ 6.9	-3.8
			R	22.6 $\pm$ 7.2	22.5 $\pm$ 6.3	-0.5
Children (n=172)	M n=61	YOGA	L	20.8 $\pm$ 5.7	22.7 $\pm$ 5.9***	8.9
			R	22.3 $\pm$ 6.0	25.1 $\pm$ 6.5***	12.2
	F n=25	YOGA	L	18.7 $\pm$ 3.9	20.9 $\pm$ 3.3***	11.9
			R	20.1 $\pm$ 4.1	23.2 $\pm$ 4.0***	15.8
	M n=61	CONTROL	L	22.0 $\pm$ 6.4	22.2 $\pm$ 6.2	1.0
			R	24.0 $\pm$ 7.1	24.5 $\pm$ 7.0	1.8
	F n=25	CONTROL	L	18.9 $\pm$ 2.7	19.2 $\pm$ 3.3	1.9
			R	20.8 $\pm$ 2.8	22.3 $\pm$ 2.9	7.3
Patients (n=40)	M n=10	YOGA	L	23.8 $\pm$ 4.4	33.2 $\pm$ 5.3**	39.5
			R	27.0 $\pm$ 5.7	33.0 $\pm$ 5.8***	22.2
	F n=10	YOGA	L	8.5 $\pm$ 3.1	21.1 $\pm$ 3.9***	148.2
			R	10.2 $\pm$ 3.0	22.6 $\pm$ 4.3***	121.6
	M n=10	CONTROL	L	18.7 $\pm$ 6.9	18.4 $\pm$ 8.4	-1.6
			R	18.4 $\pm$ 5.4	18.6 $\pm$ 7.1	1.1
F n=10	CONTROL	L	10.3 $\pm$ 4.6	10.9 $\pm$ 3.1	5.3	
		R	11.7 $\pm$ 3.8	11.4 $\pm$ 3.0	-2.6	

\*\*\*P<. 001, \*\*P<. 002, t-test for paired data, 'after' compared to 'before' for yoga and control groups separately

change where significant are given in Table II.

Among normal volunteers the percentage increases following yoga were comparable for male adults and children, for both hands after 30 days (for adults) and 10 days (for children) of yoga, respectively. However, for adult females following 30 days of yoga, the

percent increase in grip strength was almost double that of girls after 10 days of yoga, and was also almost double that of adult males, who also received 30 days of yoga training. Percentage increase of boys and girls were comparable. Patients, who were all adults, showed greater percentage increase following 15 days of yoga compared to normal adults after 30 days of yoga.

Among patients, female patients showed an increase which was about thrice the increase observed in male patients.

The actual values (rather than percentage increase) showed that at baseline (i) adult male volunteers and patients had higher grip strength than corresponding female subjects (volunteers and patients, respectively). (ii) The gender difference in improvement in grip strength following yoga was smaller between boys and girls. (iii) For all categories of subjects right hand grip strength was greater than that of the left hand.

Finally, the drug score data were analyzed. There was a significant reduction in Drug Score following 14 days of yoga, as values changed from  $2.20 \pm 1.4$  (Day 1) to  $0.60 \pm 0.5$  (Day 14) [ $P=0.013$ ]. The control group showed no change. The values were:  $3.16 \pm 1.6$  (Day 1) and  $1.83 \pm 1.3$  (Day 14) [ $P=0.22$ ]. It should be noted however, that at baseline the two groups differed in the following points, viz., (1) 10 of the yoga group were on NSAIDs, versus 6 of the control group, with 20 patients in both cases (2). The drug scores of the 6 control group patients were higher than those of the 10 yoga group patients at baseline, which may also account for differences in the results of the two groups.

## DISCUSSION

The present study has shown that following yoga practice adult and child volunteers and patients with rheumatoid arthritis show significant increases in hand

grip strength. At baseline, as expected, adults show higher values than children, and males compared to females (4). The magnitude of increase in grip strength following yoga was maximum for female patients (about thrice the percentage increase observed in male patients, even though the yoga program and the duration were the same), followed by female volunteers whose percentage increase was about double that of male volunteers.

Yoga practice has already been shown to improve grip strength in adult male volunteers trained in physical education (9), in children whose yoga program emphasized *pranayama* (8), and in patients with rheumatoid arthritis who practiced yoga as a single session per day (2). The improvement in hand grip strength after yoga practices, emphasizing *pranayama*, was ascribed to the oxygen requirement-reducing effect of *pranayama*, as the availability of energy and oxidation of glucose is believed to influence the hand grip strength proportionately (5). However, the increase in hand grip strength following other yoga practices, including *pranayama* could be due to different factors including cognitive components and non-specific arousal (7).

Rheumatoid arthritis patients of the present study showed significant improvement in hand grip strength, whereas patients of an earlier study (2), showed a non-significant trend of improvement. This difference could be related to the fact that the patients of the present study had an

intensive, though short duration program. These results may also suggest that improvement may be more rapid following a short-term intensive yoga training program (i.e., in this case 15 days), as opposed to a longer duration (i.e., 8 weeks followed by 3 months), much less intensive program, as described earlier (2). The present study has also shown differences in the percentage increase of improvement in hand grip strength after yoga, related to hand dominance, age, and gender. Right hand values were greater than left hand values, and females showed greater percentage improvement than adult males both for normal volunteers and patients. The

exact reason for this difference is not known.

Hence the present results have shown that yoga practice increases hand grip strength, with different magnitudes of percent change depending on gender and age. However it should also be noted that the results, especially the magnitude of change in grip strength following yoga, may have been related to the fact that the values at baseline were lower than for the control group, hence there was greater scope for improvement in the yoga group, to begin with.

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