

Original Article

Immediate changes in muscle strength and motor speed following yoga breathing

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Abstract

The present study was conducted to assess the immediate effect of high-frequency yoga breathing on muscle strength and motor speed. Bilateral handgrip strength, leg and back strength, finger tapping and arm tapping speed were assessed in fifty male participants (group mean age \pm SD, 26.9 \pm 6.2 years) before and after (a) high frequency yoga breathing for 15 minutes and (b) breath awareness for the same duration. Sessions (a) and (b) were on two different days but at the same time of the day. The schedule was alternated for different participants. There was a significant increase ($P<0.05$) in right hand grip strength after high frequency yoga breathing. Both finger and arm tapping improved after both practices. The results suggest a role for high frequency yoga breathing in improving the hand grip strength as an immediate effect.

Introduction

Bilateral handgrip strength is an objective anthropometric measure used in varied situations. Examples include determining work capacity (1), the extent of injury and disease, as well as the potential for and progress in rehabilitation (2). Isometric back strength and leg strength are also recognized anthropometric assessments. The efficiency of muscle function is also determined by the ability to perform successive, rapid alternating movements quickly and without fatigue, which is assessed by the tapping speed (3).

Yoga practice includes specific postures (*asanas*), breathing techniques (*pranayamas*), and meditation, among other practices (4). Previously, three months of practicing a combination of yoga techniques, increased the bilateral hand grip strength in male physical education teachers, who had an average of nine years experience in the profession (5). School children, aged between twelve and 15 years also showed improved hand grip strength after ten days of practicing various yoga techniques (6). Individuals with rheumatoid arthritis who had pain and swelling of the finger joints showed an improvement in hand grip strength following a yoga session five times a week, for eight weeks, followed by weekly two-hour sessions for three months (7). These studies assessed the effect of yoga practiced over a period of time on hand grip strength.

Yoga practice also increased tapping speed in children after ten days and in adults after a month (8). For both groups, the tapping speed increased during the first ten seconds of the test, but not during

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(received on February 12, 2013)

the next 20 seconds, suggesting an initial spurt of speed which was not sustained.

Apart from this, two months of yoga practice (for 45 minutes, 5 days in a week) improved tapping speed in people who used a computer for more than five hours a day, and were vulnerable to develop repetitive stress injury (9).

Studies on immediate changes in hand grip strength and tapping speed are fewer. For example, a decrease in hand grip strength was reported in 11 expert-level rock climbers when post-climb values were compared to pre-climb values, and the mean climbing time was 12.9 minutes (10). Other interventions for which the immediate effect was studied include application of a local anesthetic on fore-arm skin (11), or exposure to low-frequency hand-arm vibration (12). Both of them had no effect on grip strength.

There have been no studies assessing whether yoga practice can bring about immediate changes in hand grip strength or tapping speed. The present study was planned to assess the effect of 15 minutes of a high frequency yoga breathing practice (with breath rate approximately 1.0 Hz) on hand grip strength, leg and back strength, and tapping speed. High frequency yoga breathing was chosen since this technique has been traditionally described as having an energizing effect (13). Participants were asked to practice breath awareness on another day. Breath awareness was chosen as breath awareness improved performance on an attention task (14), which is associated with increased sympathetic activity (15) and increased sympathetic activity is associated with improved static hand grip (16).

Methods

Participants

Fifty male participants between the age of 18 and 40 years (group mean age \pm SD, 26.9 \pm 6.2 years) took part in the study. The sample was not determined statistically prior to the experiment. However *post-hoc* analyses show that for the present study, with

the sample size as 50, and with the effect size obtained, the power was 0.3836 (17). Participants were staying at a residential yoga center located in north India and all of them had approximately the same experience of practicing the two techniques (six months). Participants were included if they were (i) healthy and (ii) right hand dominant (18). The hand grip strength is known to differ based on which hand is dominant. In two hundred and fourteen adults, right hand dominant subjects were 10 percent stronger in grip strength on the dominant side (19). In left handed subjects mean grip strength was the same for both hands, the non-dominant hand was stronger in 50 percent of left-handed subjects. Hence in the present study to avoid the effect of handedness influencing the results, right hand dominant subjects alone were included. Participants were excluded if they were using (i) tobacco, intoxicants or any caffeinated beverages and (ii) any medications.

Participation in the study was voluntary and signed informed consent was obtained. The study was approved by the institution's ethics committee. Baseline characteristics of the participants are given in Table I.

TABLE I: Baseline characteristics of the participants.

<i>Characteristics</i>	<i>Group mean\pmSD</i>
Age (years)	26.9 \pm 6.2
Blood Pressure (mmHg)	
• Systolic BP	116.2 \pm 6.5
• Diastolic BP	69.8 \pm 5.8
Respiration rate (breath per minute)	14.6 \pm 1.7
Disease	None
Medication	None

Study design

Data were acquired on four different days. Participants were alternately allocated to the two practices, viz., high frequency yoga breathing and breath awareness. The assessments, viz., (a) bilateral hand grip strength, (b) leg and back strength, (c) finger tapping speed, and (d) arm tapping speed were taken in all participants, following the same method. The assessments were made immediately before and after the two breathing practices. On two alternate days the participants were assessed for hand grip strength and leg and back strength, before

and after high frequency yoga breathing and breath awareness. On the other two alternate days the participants were assessed for finger tapping speed and arm tapping speed, before and after high frequency yoga breathing and breath awareness. The design is schematically shown in Fig. 1.

Assessments

Hand grip strength

Hand grip strength was assessed using a grip dynamometer (Lafayette Instrument, Model 78010, U.S.A). Participants were tested in six trials, 3 for each hand alternately, with a ten second gap between trials. During the assessment, participants were asked to keep their arm extended at shoulder level, horizontal to the ground and grip the dynamometer with maximum effort. The maximum value obtained during the trials was used for analysis.

Leg strength and isometric back strength

Leg strength and isometric back strength were measured using a leg and back dynamometer (Takei Model 5402, Japan). Participants were tested in a single trial. During the assessment participants were asked to exert maximum force with their legs and back to pull the chain of the dynamometer upwards.

Finger tapping

Finger tapping was assessed with a plastic board raised on one side by an angle of approximately eight degrees to the horizontal, providing an incline on which the wrist could rest while tapping (Lafayette Instrument, Model no. 32726 U.S.A). The tapping motion would depress a metal bar, connected to a counter, so that each tap would increase the reading by '1'. The counter could be manually reset to zero. Participants were asked to tap the metal bar with the index finger of the dominant hand as many times as possible during a period of 60 seconds. The number of taps was noted at the end of every ten seconds, for 60 seconds.

Arm tapping

Arm Tapping was assessed using an apparatus which

has a metal stylus connected to it and contact between the stylus and two metal plates were registered on an impulse counter (Lafayette Instrument, Model no. 32012 U.S.A). Participants were instructed to use their dominant hand to hold the stylus and tap both sides (right and left) of the board and were asked to tap as rapidly as possible. The wrist was not supported and the stylus was held as a pen is held. Tapping speed was assessed in six contiguous periods (i.e. every ten seconds for 60 seconds).

Intervention

The two interventions were given on two different days for each participant and allocation to either intervention was alternated. The total time for the interventions was 18 minutes. During high frequency yoga breathing, participants practiced high frequency yoga breathing (at 1.0 Hz) with forceful exhalation, as three periods of five minutes each. After each five-minute period there was a one-minute gap during which they breathed without modifying their breath.

During the practice of breath awareness participants were asked to sit in a cross legged position and sit quietly, being aware of the temperature and flow of air through the nasal passages. Breath awareness was selected as an alternate intervention, as being aware of one's breath is an essential part of all yoga breathing, including high frequency yoga breathing.

Data analysis

Statistical analysis was done with SPSS version 18.0. A repeated measures analyses of variance to analyze the data for right hand grip strength, left hand grip strength, leg and back strength, and tapping speed was done. For right hand grip strength, left hand grip strength and leg and back strength each ANOVA contained two Within-Subjects factors i.e., Sessions (high frequency yoga breathing, breath awareness) and States (pre, post). For the tapping speed tests there were separate ANOVAs for finger tapping and for arm tapping. Each ANOVA had three within-subjects factors. These were: Sessions (high

frequency yoga breathing, breath awareness), States (Pre, Post) and Trials (10, 20, 30, 40, 50, and 60 seconds).

An ANOVA was followed by *post-hoc* analysis with Bonferroni adjustment.

Results

Analyses of variance

(a) Handgrip Strength

For right hand grip strength there was a significant interaction between Sessions and States, suggesting that the two were interdependent ($F = 4.26$, $df = 1,49$; $P < 0.05$).

(b) Finger tapping speed

The repeated measures ANOVA showed a significant difference between the States ($F = 15.69$, $df = 1,49$, $P < 0.001$), Trials ($F = 788.38$, $df = 1.26,61.89$, $P < 0.001$), and interaction between States and Trials ($F = 11.93$, $df = 4.55,223.26$, $P < 0.001$; Huynh-Feldt $\epsilon = 1.000$). There was no significant difference between Sessions.

(c) Arm Tapping

The repeated measures ANOVA showed a significant difference between the States ($F = 69.22$, $df = 1,49$, $P < 0.001$), Trials ($F = 2142.04$, $df = 2.07,101.46$, $P < 0.001$; Huynh-Feldt $\epsilon = .414$), and interaction between States and Trials ($F = 11.28$, $df = 3.26,159.87$, $P < 0.001$; Huynh-Feldt $\epsilon = .653$). There was no significant difference between Sessions.

Post-hoc analyses

(a) Handgrip strength

There was an acute increase in right hand grip strength after high frequency yoga breathing practice compared to before ($P < 0.05$; *post-hoc* analyses for multiple comparisons with Bonferroni adjustment).

(b) Finger tapping

Post-hoc analyses with Bonferroni adjustment and pair-wise comparison of values of tapping speed in ten second time intervals was carried out. Following high frequency yoga breathing there was a significant increase in finger tapping speed at all six time points studied, from ten seconds to 60 seconds ($P < 0.001$). All participants also showed significant increases in finger tapping speed at the six time points studied (from ten seconds to 60 seconds) after breath awareness ($P < 0.001$).

(c) Arm Tapping

Post-hoc analyses with Bonferroni adjustment by pair-wise comparison of values of tapping speed in ten second time intervals was done. Following high frequency yoga breathing all participants showed significant increases in arm tapping speed at all six time points studied, from ten seconds to 60 seconds ($P < 0.001$). All participants also showed significant increases in arm tapping speed at all six time points studied, from ten seconds to 60 seconds after breath awareness ($P < 0.001$).

For muscle strength group mean values \pm SD, are given in Table II, while for tapping speed group mean values \pm SD, are given in Table III.

TABLE II: Changes in grip strength and leg and back strength following High frequency yoga breathing and Breath awareness in fifty male participants. Values are in group mean \pm SD.

Variables	High frequency yoga breathing		Breath awareness	
	Before	After	Before	After
Right hand grip strength (kg)	40.66 \pm 6.54	41.44 \pm 6.36*	40.42 \pm 6.95	40.52 \pm 6.88
Left hand grip strength (kg)	38.72 \pm 6.41	39.02 \pm 6.28	38.36 \pm 6.78	38.40 \pm 6.38
Leg and back strength (kg)	113.39 \pm 18.73	115.24 \pm 18.20	115.51 \pm 19.98	116.90 \pm 20.22

* = ($P < 0.05$), After values compared to Before.

TABLE III: Finger tapping speed and Arm tapping speed following High frequency yoga breathing and Breath awareness in fifty male participants. Values are in group mean±SD.

Sessions	Variables	States	Time (in seconds)					
			10	20	30	40	50	60
High Frequency Yoga Breathing	Finger tapping speed	Before	39.80±16.11	81.24±28.87	121.34±38.69	157.42±48.32	201.38±61.01	247.24±68.66
		After	51.40±15.79***	92.84±26.72***	139.92±33.12***	181.50±44.57***	230.96±54.90***	274.96±62.30***
Yoga Breathing	Arm tapping speed	Before	39.50±8.10	77.04±14.19	113.12±21.36	154.20±23.33	191.70±35.48	230.08±34.68
		After	43.30±6.18***	87.20±19.36***	128.18±16.52***	173.26±20.07***	210.10±20.17***	247.58±42.34***
Breath Awareness	Finger tapping speed	Before	41.74±14.85	84.26±26.56	127.52±35.46	169.16±44.42	208.68±53.81	254.58±64.96
		After	52.30±14.54***	95.72±28.31***	139.00±36.32***	188.30±47.96***	228.16±52.57***	276.02±63.91***
	Arm tapping speed	Before	39.66±6.57	75.68±15.38	112.36±21.02	147.00±25.82	184.30±36.24	218.24±43.17
		After	43.32±7.71***	83.94±15.46***	123.12±30.18***	165.96±27.73***	208.30±33.32***	248.58±30.56***

*** = (P<0.001), After values compared to Before.

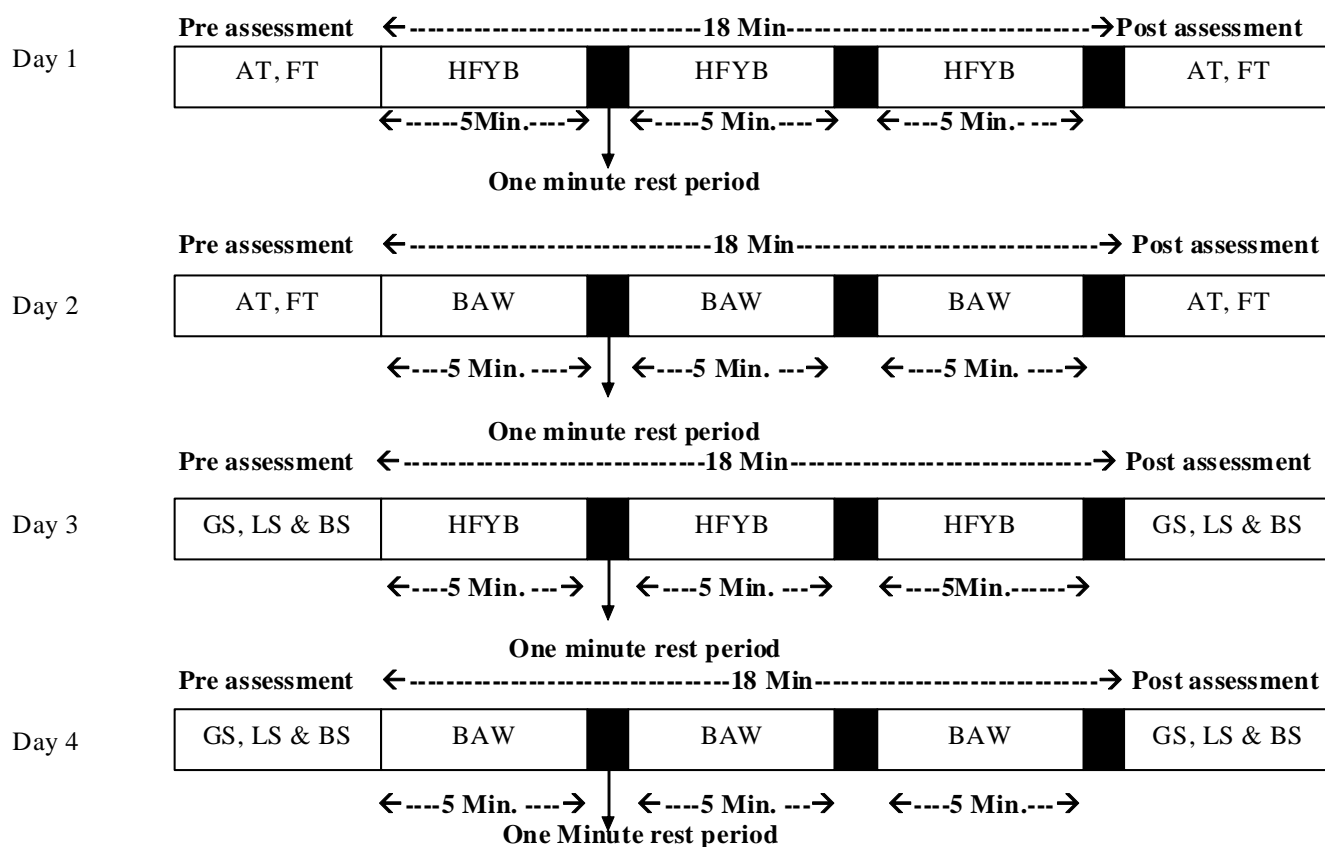


Fig. 1: Schematic presentation of the study design.

HFYB; High frequency yoga breathing; BAW; Breath awareness; AT = Arm tapping; FT = Finger tapping; GS = Grip strength; LS = Leg strength; BS = Back Strength.

Discussion

At the end of fifteen minutes of high frequency yoga breathing, at the rate of approximately 1.0 Hz, there was a significant increase in right hand grip strength. It was mentioned in the introduction that increases

in hand grip strength have been reported previously when different yoga techniques were practiced over a period of time. The present study reports an immediate increase in right hand grip strength following high frequency yoga breathing. There were no changes in left hand grip strength or leg and

back strength, and no changes after breath awareness. Finger and arm tapping speed improved comparably after both high frequency yoga breathing and breath awareness.

Improvement in hand grip strength when yoga practitioners were assessed at the beginning and end of different periods, the minimum duration of which was ten days, was ascribed to the possible effects of yoga breathing techniques or *pranayamas* (20). These effects were a reduced oxygen consumption following yoga breathing (*pranayama*), along with changes in the availability of energy and oxidation of glucose which would influence hand grip strength. It is not known whether the high frequency yoga breathing studied here increases or reduces the requirement of oxygen in the muscles, as an immediate or short-term effect of the practice. However an inference may be drawn from an earlier study. In this study, high frequency yoga breathing practiced for one minute at the rate of 2.0 Hz, in 12 normal healthy males resulted in an increase in urinary creatinine (21). In another study exercise performed at approximately 45 percent of VO_2 max for 90 minutes resulted in an increase in urinary creatinine (22), which was believed to be due to an increase in net protein catabolism, though there was no disproportionate breakdown of myofibrillar contractile proteins. In the study mentioned above, by Desai and Gharote, 1990 (21), high frequency yoga breathing practiced for one minute may have resulted in increased protein catabolism and hence increased urinary creatinine. It is unlikely that in the present study urinary creatinine levels would have been high, as grip strength and urinary creatinine levels are negatively correlated (23). This difference could be due to the fact that in the study by Desai and Gharote, 1990 (21), high frequency yoga breathing was practiced at 2.0 Hz for a minute, whereas in the present study, high frequency yoga breathing was practiced at approximately 1.0 Hz, for 15 minutes, as three five-minute epochs with one minute rest periods in between. However since urinary creatinine was not measured, this remains a speculation.

The increase in right hand grip strength could also be due to an increase in skeletal muscle blood flow, as high frequency yoga breathing practice is

associated with increased sympathetic nervous system activity (24). This speculation is based on the fact that increased sympathetic nervous system activity is associated with increased static hand grip strength (16). Previous studies have shown an increase in cardiac sympathetic nerve activity following the practice of high frequency yoga breathing, based on an analysis of the spectral components of heart rate variability (24). Apart from this, high frequency yoga breathing was associated with higher systolic and diastolic blood pressure levels, which could be suggestive of higher sympathetic tone.

The reason why high frequency yoga breathing increased hand grip strength, but not leg and back strength could be due to differences between the muscle groups involved in the two assessments. Tests for leg and back strength involve muscles of the torso (e.g., *rectus abdominis*, *obliquus externus abdominis*); of the back (e.g., the *rhomboides* along with other muscles), and muscles of the legs (e.g., *quadriceps*) and hips (e.g., *gluteal* muscles) (25). These muscles consist of slow oxidative or slow twitch fibers which are resistant to fatigue, and have a high capacity to generate ATP by oxidative metabolic processes, which are possibly less likely to show acute changes following a particular practice. In contrast hand grip strength involves muscles such as *pronator radii teres*, *flexor carpi radialis* and *flexor carpi ulnaris*, among others (26). These muscles consist of fast glycolytic or fast twitch fibers, which fatigue easily. They may hence be favorably affected by a yoga breathing practice which facilitates generation of energy by oxidative processes, as recently the practice of high frequency yoga breathing was found to increase the availability of energy from different sources such as carbohydrates and fats. The practice of high-frequency yoga breathing increased the ease with which energy was made available from these sources, based on a study of the oxygen consumed during the practice (27). The fact that carbohydrates release energy quicker than fats may suggest that the short-term effects are due to energy derived from carbohydrates (28). This may have contributed to the acute increase in right hand grip strength, seen here.

There appears to be no specific reason why right hand grip strength alone increased. All participants were right hand dominant, but pre-intervention grip strength scores of right and left hands were not significantly different. There is no clear explanation for this. Certain structural and functional differences exist between the right and left hand. Yoga practice has been shown to influence these factors and hence may cause changes in the right hand alone. The structural differences include more pyramidal tract fibers directed to the right than the left hand in about 75 percent of persons (29). Studies have shown that yoga practice can improve cortical functioning (30) and yoga practice can even cause structural changes in the cerebral cortex (31). While the changes mentioned in these reports (30, 31) were not specifically seen in the motor cortex or pyramidal tracts, one may speculate that these areas could possibly have changed in their functioning, if not their structure after six months of yoga practice, which was the experience of the present group of participants.

There are other structural differences between the two hands. In 992 participants anter-postero hand radiographs showed a pattern of asymmetry in left-handers as well as right-handers (32). Increased bone strength based on periosteal and endosteal thickness of the second metacarpal was seen on the dominant side. In a separate study Yoga practice was shown to increase bone mineral density measured by single-photon absorptiometry along with hand grip strength in 649 post-menopausal women (33). Participants who increased physical activity, which included yoga, had significant associations of grip strength with bone

mineral density. It is not known whether such a change in bone structure would have occurred in the participants of the present study who had experience of yoga for 6 months, though it is possible that it may have occurred.

Both finger tapping and arm tapping increased following both high frequency yoga breathing and breath awareness. The increase was comparable. In the absence of a no-intervention control group, it cannot be ruled out that this increase was due to a practice effect. However the results show that both interventions did increase the speed for repetitive movements.

The limitations of the study include (i) the fact that the study was limited to males, (ii) the changes which occurred as an immediate effect of high frequency yoga breathing or breath awareness, are less easy to explain compared with longitudinal changes and (iii) There were no measurements to support the hypothesized mechanisms underlying the change, such as better oxygenation of the muscles.

The present results suggest that high frequency yoga breathing practice may bring about a small yet significant increase in right hand grip strength. This may explain why yoga programs which included high frequency yoga breathing improved grip strength in patients with rheumatoid arthritis (34).

Conflict of Interest

The authors state that there is no conflict of interest.

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