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Research article

A randomised placebo-exercise controlled trial of Kung Fu training for improvements in body composition in overweight/obese adolescents: the "Martial Fitness" study

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Abstract
The purpose of the study was to investigate if Chinese martial arts (Kung Fu, KF) might be effective for improving body composition, as well as being an appealing form of physical activity for inexperienced, sedentary, overweight/obese adolescents. Twenty subjects (age: 13.3±1.8 y; BMI percentile: 98.6(86.5 – 99.8); 60% girls) were randomly-assigned to the supervised KF or placebo (Tai Chi, TC) control group 3 d.wk^{-1} for 6 months. We assessed body composition, including total and regional fat and lean mass, total and regional bone mineral density (BMD), percent lean and fat mass, body mass index and waist circumference, at baseline and after 6 months of training using anthropometry and dual-energy X-ray absorptiometry (DXA). Habitual physical activity and dietary intake were recorded as covariates via self-report at each time-point. As expected due to natural growth, significant increases in height, weight, total and lumbar BMD, and lean mass were seen in the cohort over time, with a trend for increased whole body fat mass, with no difference between groups. By contrast, percent fat and android fat mass via DXA did not increase in either group over time. The absence of a similar expected increase in central adiposity over 6 months could indicate a positive effect of participation in both programs on the metabolically critical abdominal adiposity in this cohort. Further research in this area is warranted to determine ways to increase uptake and compliance, and to see if longer-term martial arts training not only maintains, but improves abdominal fat mass and related metabolic health indices in overweight/ obese adolescents.

Key words: Adolescents, Obesity, Exercise, Martial arts.

Introduction

Adolescent obesity is associated with a range of problems pertaining to physiological and mental health, physical function, and early morbidity and mortality (French et al., 1995, Pender and Pories, 2005, Swallen et al., 2005; Zanconato et al., 1989). Although obesity is theoretically manageable by lifestyle changes including increased physical activity and dietary restriction (Bar-Or et al., 1998, Roberts, 2000), the fact that up to 63% of overweight children and adolescents end up overweight as adults (Serdula et al., 1993) indicates that obesity in youth is often not successfully treated.

Various forms of physical activity have been shown to improve body composition, health and fitness in overweight adolescents, even without dietary intervention (Gutin et al., 1995; 2000; LeMura and Maziekas, 2002; Owens et al., 1999), however with the increasing prevalence of adolescent obesity worldwide (Batch and Baur, 2005; Cash et al., 2004; Strauss and Pollack, 2001; Wiegand et al., 2004), it is apparent that recommendations from these studies are not being successfully implemented. It would be of interest to examine the efficacy of a form of physical activity which traditionally requires long-term commitment and may become a way of life (Theeboom and De Knop, 1997), but which is not necessarily as prolonged or continuous in nature during training sessions. Intermittent or interval exercise has been shown to be better tolerated than continuous exercise by obese adults in the past, and it has been suggested that the better-tolerated intermittent exercise would therefore result in higher adherence in this cohort than continuous exercise (Coquart et al., 2008). An example of such an exercise form, which incorporates both features aforementioned (i.e., requires commitment and is often intermittent), is martial arts. It is possible that a more varied form of exercise such as this would be feasible and attractive to overweight adolescents, particularly if presented to them as a beneficial form of exercise for health. To our knowledge, only three studies (two randomized controlled trials, one report of a program) of normal weight and obese/morbidly obese youth, in the past have included martial art techniques in combination with other physical activities in their interventions (Falk and Mor, 1996; Rosenbaum et al., 2007; Sternberg et al., 2006). However, no clinical trials have examined the benefits of "pure" or traditional martial arts training, reflective of traditional martial art classes, in previously untrained children or adults.

Therefore, the primary aim of this trial was to examine the effect of a six-month Kung Fu (KF) intervention on total (%) and abdominal fat mass in overweight and obese adolescents compared to placebo training (Tai Chi, TC). Secondary body composition outcomes included total and regional lean mass and bone mineral density. We hypothesized that KF training would result in improved body composition (less fat, more muscle and bone) relative to changes in observed in the TC group over time.

Methods

Study design

The study was a randomized placebo-controlled trial.

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Baseline testing and primary outcomes (DXA-derived body composition) as well as questionnaires were double-blind at both time-points. Secondary anthropometric outcomes and adverse events were single-blind (subject only, as control group was placebo exercise). Ethics approval was obtained from The Children's Hospital at Westmead (CHW) and The University of Sydney, Australia. This trial was registered with the Australian New Zealand Clinical Trials Registry (ANZCTR: 012605000716662)

The primary outcomes were percent body fat (BF) and android fat mass, measured using dual-energy X-ray absorptiometry (DXA), which is relatively low-cost (Park et al., 2002), simple (Ogle et al., 1995), and involves minimal exposure to radiation (Ogle et al., 1995, Park et al., 2002). Sample size was based on total body fat mass, as comparable estimates in the literature were available, in contrast to the android adiposity measurement. Based on previous research (Ferguson et al., 1999; Gutin et al., 1997; Owens et al., 1999), we hypothesized that total BF would decrease more in the KF group than in the placebo group with changes ± SD of -2.8 ± 4.0% in the KF group and -0.2 ± 2.91% in controls, corresponding to a mean effect size of 0.9. Power (beta) was set at 0.80, and alpha at 0.05, which determined that a total sample size of 40 was needed. An average dropout rate of 5% (Ferguson et al., 1999; Gutin et al., 1997; Owens et al., 1999) was factored in, resulting in a total sample size requirement of 42.

Eligibility and exclusion criteria

Included were subjects who were in school years 6 to 12, overweight/obese (International BMI cut-off points for children aged <18 y, based on age and gender) (Cole et al., 2000), and sedentary (not partaking in >2 $h.wk^{-1}$ of regular, organized physical activity/sports or exercise (excluding compulsory physical education classes) within the last 4 months. Subjects had no previous experience with martial arts of any style within the past year, nor any other commitments that interfered with their participation in all scheduled exercise and testing sessions.

Subjects were excluded if they had: any cognitive, visual, mobility, or congenital/genetic/growth impairment or disorder; any condition that might be worsened by the exercise or testing procedures; type 1 diabetes; amputation proximal to the fingers and/or toes; or if they had fractured a limb within the past six months. Subjects who were participating in other research studies which might affect or be affected by their participation in the current study, as well as those who were pregnant were also excluded.

Recruitment and screening

Subjects were recruited from CHW as well as from the general community via advertisements, referrals, and word-of-mouth. Those who were interested in joining contacted the assessor and underwent an interview over the telephone. A "Telephone Screening Form" was used by the assessor (TWT) to guide the interview, which was developed for the trial based on the inclusion and exclusion criteria. Subjects who were deemed potentially eligible after this interview were invited to attend the study clinic for baseline measurements and a physical examination (and maturation assessment using the Tanner method (Faulkner, 1996; Tanner, 1981) by the study physician (MK). Informed consent was obtained from subjects and their parent/guardian at the first assessment session also.

Outcome measures

Body composition: The primary outcomes were total BF (CV = 0.19%) and android (abdominal) fat, measured using DXA (GE Lunar Corp, Madison, WI). The android region (coefficient of variation, CV = 1.45%), was defined by the software (version 8.6) as being $1/5^{th}$ the trunk height, with the inferior border placed on the iliac crests. The width of the region was equal to the width of the trunk at that level. Secondary DXA outcomes included percent BF, total and percent lean body mass (LBM) (CV = 0.16%), arms LBM (CV = 0.52%), legs LBM (CV = 0.47%), and bone mineral density (BMD) of the femoral neck (CV = 1.22%), lumbar spine (L_2 – L_4) (CV = 0.28%), and whole body (CV = 0.06%). Only in the presence of an abnormality in the dominant femoral neck (e.g., metal pin implant), was the non-dominant side scanned. For subjects who were too wide for the scan bed, their arms were tightly bound using a transfer sheet. At times the technician additionally had to physically hold the subjects' bound arms in place to ensure their entire body remained within the boundaries of the scan bed.

Fasting anthropometric measures obtained included height (CV = 0.05%), weight (CV = 0.05%), and waist circumference (CV = 0.11%). Height and waist circumference (using the International Standards for Anthropometric Assessment protocol (Norton et al., 1996)) were measured in triplicate to the nearest millimetre, and additional measures were taken if any two measurements deviated >1 cm from each other.

Questionnaires: Instructions and rationale for all questionnaires were first explained to the subjects, before they were asked to answer the questions themselves. They were encouraged to ask the assessor if they had any questions.

Weekly status check: Each week throughout the six-month training period, each subject was asked to complete a Weekly Status Check questionnaire during the exercise session. The questionnaire asked subjects to provide details about any illnesses, injuries, or new symptoms they may have experienced during the previous week, any changes in their medications, visits to health care professionals, and reasons for any missed exercise sessions. These questionnaires were completed via interview over the phone if a subject did not attend the sessions during a given week. These questionnaires were also used to capture adverse events and changes in health status, related or unrelated to study participation. Possible adverse events defined *a priori* included new physical or mental symptoms of any kind, and any injuries sustained during or outside of the training sessions.

Patient satisfaction (follow-up only): A multiple choice questionnaire was created for this study, asking subjects how much they agreed or disagreed (on a 5-point Likert scale) with statements referring to aspects of the exercise classes. Included were statements about how difficult it was to perform the movements and attend all exercise classes, if subjects felt physically or emotionally better after the training period, and if they would recommend this form of exercise to their friends.

Covariates

Nutritional intake and habitual physical activity were monitored over 5 – 7 consecutive days (including a weekend) at baseline and follow-up. Subjects and their parents/guardians were asked not to change what activities they normally did or what they normally ate. Parents/guardians were asked to assist with the data recordings if necessary, and to ensure proper use and maintenance of the monitoring devices. The assessor provided demonstrations and instruction sheets for all devices.

Habitual physical activity: Habitual physical activity was reported using the PACE+ (Patient-centred assessment and counselling for exercise) questionnaire (Prochaska et al., 2001), enquiring about the frequency and duration of any moderate to vigorous physical activity habits (MVPA) over the previous seven days. Trial exercise sessions were not to be included when answering this questionnaire.

Dietary intake: Self-reported food and drink intake was recorded using CONIA digital MP3 players with voice recording capabilities (Model: CMP51206, Pebble Electronics Pty Ltd, Knoxfield, Vic), similarly to previously reported (Van Horn et al., 1990). Whenever subjects consumed any food/drink, they were to record the date, time, food/drink description (name/brand/cooking method), and quantity consumed, including details of any condiments and water intake. Parents/guardians were asked to help also, especially in cases where they prepared the meal. If subjects did not want to take the MP3 player to school (in fear of losing it or having it confiscated), they were instructed to write the information down on a piece of paper. They could either record it into the MP3 player at home after school or give the assessor the written logs also.

Data recorded on MP3 players were downloaded and transcribed by the assessor, who contacted the subject again for clarification of details if any recordings were unclear. Food/drink data were analyzed for macronutrient composition using AusNut Database from the Foodworks Professional Edition software, version 3.02.581 (Xyris Software (Australia) Pty Ltd, Highgate Hill, Qld). Average energy, protein, fat (total, saturated, polyunsaturated, and monounsaturated), cholesterol, carbohydrates, sodium, and sugars consumed were recorded, and also proportion of energy contributed by intake of protein, fat, and carbohydrate.

Randomisation

Subjects were randomly assigned to either the KF or TC (placebo-exercise-control) group after completing all baseline assessments. Randomisation was performed by a researcher (MFS) who had no contact with any of the subjects, using a computer randomisation program (Dallal, 2003). Subjects were stratified by gender and BMI category (overweight vs. obese). After randomisation, MFS informed the assessor (TWT) of the subject's group allocation, and the subject was informed via telephone by the assessor.

Training interventions

Both groups were offered three, one-hour sessions each week of either TC or KF training, over a period of six months. Classes were held by one instructor per class, and TC and KF classes were held at the same time, in different rooms within the hospital to avoid contamination, by subjects seeing what was happening in the other group's sessions. All sessions began with warm-up exercises specific to the martial art, and a short (1 – 2 min) drink break was provided in the middle of each session. All instructors were told to refrain from providing any lifestyle, behavioural, or dietary advice, and to also avoid encouraging (or even mentioning) home practice of the exercises taught. Attendance was recorded by the instructors at each session, while adverse events (whether or not related to study participation) were reported by subjects each week via questionnaire or telephone interview (for those who did not attend in a given week).

Kung Fu sessions: The KF group was taught basic KF techniques of the Choy Lee Fut Hung Sing Gwoon style. Training involved non-contact technique practice and technique practice on focus mitts and kicking shields, and learning and practice of basic forms. Sessions were usually intermittent in nature, as the instructor often needed to stop the class to correct, demonstrate, and explain techniques. As an estimate, sessions would have been active for a minimum of approximately 40 min (out of 60 min). All KF sessions were generally run by the same instructor.

Tai Chi sessions: TC has previously been shown to have no effect on metabolic outcomes or body composition (Tsang et al., 2008), so was used in this trial as the placebo exercise. Yang style TC was selected, because its broad, aesthetically-pleasing movements were thought to be more appealing to our young cohort than other TC styles. The Yang 24 forms were taught progressively to the TC group, with quiet Chinese music playing in the background. The TC instructors were externally-hired from a TC school, so sessions were run by a select group of instructors, depending on each individual TC instructor's availability.

Statistical analysis

Statistical analyses were performed using Statview, version 5.0 (SAS Institute, Cary, NC). All data were visually and statistically inspected for normality of distribution. Non-normally-distributed data were log-transformed, or if necessary, transformed using $1/x$. All values were reported as mean ± SD; non-normally-distributed data reported as median (range). Baseline comparisons (mean differences, confidence intervals (95% CI), t tests, and chi square tests) and changes over time between groups were compared using repeated measures analysis of variance (ANOVA) for continuous variables. Variables with statistical or clinically meaningful differences between groups at baseline and potentially related to the outcome of interest were used as covariates in models. All analysis of covariance (ANCOVA) models for change scores included the baseline scores for that variable and attendance. Change scores and SD at six months were used to calculate weighted mean differences, 95% CIs, and Hedge's bias corrected effect size (ES) (Hedges and

Olkin, 1985) for each group. A *p* value of <0.05 and 95% CI excluding 0 were accepted as statistically significant. Robustness of effects was assessed by calculating ES (<0.2 = negligible; 0.2 – 0.5 = small; >0.5 – 0.8 = moderate; and >0.8 = large (Cohen, 1988)) and clinical meaningfulness (by comparing changes to the literature) of any changes observed. Forward stepwise multiple regression analyses were performed using variables which were significantly related to the dependent variable in univariate analyses to determine independent contributions to variance. An all available data design (subjects included if they had baseline and final assessments, regardless of attendance rate) was selected rather than an intention-to-treat design (ITT), due to the novelty of this efficacy trial. Data collected from subjects who did not complete all training sessions were still included in the analyses, as per the all available data statistical strategy. Thus, the results reflect the effects of the treatments on subjects regardless of compliance with the exercises sessions, in those in whom follow-up data was obtained. Missing follow-up data were not imputed.

Results

Subject characteristics

Recruitment difficulties resulted in only 20 rather than the planned 42 subjects enrolling in this trial. Among the 20 subjects recruited, twelve were randomized to the KF group, while the placebo group consisted of eight subjects. Subjects were aged 13.1 ± 2.1 y on average (KF: 13.4 ± 2.0 y vs. TC: 13.1 ± 1.6 y; p = 0.74), and 12/20 (60%) were female. Eighty percent of the subjects were classified obese for their gender and age (Cole et al., 2000), with an average BMI of 32.9 ± 6.7 kg.m^{-2} (KF: 32.1 ± 6.7 kg.m^{-2} vs. TC: 34.0 ± 7.0 kg.m^{-2}; p = 0.37), median BMI percentile of 98.6 (86.5 – 99.8) (KF: 98.3 (86.5 – 99.8) vs. TC: 99.0 (88.1 – 99.6); p=0.66), and one-half of subjects were at Tanner stage 5 (post-pubertal) for maturation.

At baseline, TC subjects had a higher number of physically active friends than KF subjects (KF: 2.8 ± 1.4; TC: 4.1 ± 1.0; p = 0.02). There were no other baseline differences between the groups.

Primary outcomes

Contrary to our hypotheses, neither total BF nor android fat mass were significantly reduced during the six-month trial in either the experimental or placebo-exercise control group (Table 1). However, the non-statistically significant reduction in percent BF (-0.63%) noted after six months was in direct contrast (approaching significance using a one-sample t-test, p = 0.09) to the anticipated fat gain of+0.3% reported in sedentary obese adolescents of the same age after six months (Figure 1, McCarthy et al.,

Table 1. Outcomes, body composition. Values are mean (±SD), or median (range) for non-normally distributed data.

	KF† Group		Control Group				Time effect	Group x time interaction
Characteristic	Baseline n=12	Follow-up n=11	Baseline n=8	Follow-up n=8	Mean difference (95% CI‡)	ES§	p	p
Body weight (kg)	84.9 (24.2)	87.2 (25.4)	90.5 (25.7)	93.6 (25.5)	-.82 (-25.10–23.46)	-.03	.0003*	.53
Height (m)	1.61 (.09)	1.63 (.08)	1.62 (1.20)	164.1 (11.4)	-1.51 (-11.55–8.52)	-.14	<.0001*	.75
BMI‖ (kg.m^{-2})	32.1 (6.7)	32.7 (7.8)	34.0 (7.0)	34.2 (7.2)	.34 (-6.33–7.01)	.05	.12	.37
BMI percentile	98.3 (86.5–99.8)	98.4 (86.3–99.8)	99.0 (88.1–99.6)	98.9 (85.2–99.6)	-.36 (-4.31–3.59)	-.09	.19	.81
Waist circumference (cm)	99.1 (17.9)	100.2 (19.3)	106.5 (16.7)	103.6 (17.1)	4.02 (-13.06–21.10)	.22	.46	<.05*
Percent BF¶	44.6 (6.6)	43.1 (7.6)	47.7 (5.3)	47.4 (5.6)	-1.24 (-7.25–4.78)	-.19	.30	.54
Fat mass (kg)	37.5 (15.0)	37.4 (15.7)	42.9 (15.4)	44.2 (15.6)	-1.38 (-16.22–13.47)	-.09	.07	.95
Android fat (kg)	2906 (1414–6285)	3113 (1107–6144)	4203 (1434–5213)	4278 (1462–5681)	-.20 (-1.71–1.31)	-.14	.36	.54
Percent LBM††	53.4 (6.1)	54.8 (7.0)	50.8 (5.0)	51.0 (5.2)	1.14 (-4.45–6.74)	.19	.31	.50
Total LBM (kg)	44.5 (9.8)	46.8 (10.5)	45.0 (10.3)	46.8 (10.2)	.54 (-9.25 – 10.32)	.05	<.0001*	.23
Arms LBM (kg)	4.9 (1.2)	5.4 (1.7)	5.1 (1.4)	5.3 (1.3)	.28 (-.95–1.50)	.21	.003*	.20
Legs LBM (kg)	15.1 (2.9)	15.8 (2.8)	15.1 (3.6)	15.5 (3.4)	.22 (-2.92–3.35)	.06	.002*	.25
Total BMD‡‡ (g.cm^{-2})	1.11 (.16)	1.14 (.16)	1.09 (.14)	1.11 (.14)	.0 (-.14 –.15)	.02	<.0001*	.83
Femoral neck BMD (g.cm^{-2})	1.09 (.23)	1.10 (.20)	1.01 (.20)	1.05 (.19)	-.04 (-.25–.18)	-.15	.11	.10
L_2-L_4 BMD (g.cm^{-2})	1.01 (.7–1.4)	1.08 (.7–1.4)	.99 (.80–1.30)	1.06 (.9–1.4)	-.04 (-.25 –.18)	-.17	.001*	.16

P values were generated between treatment groups from independent t-tests for continuous data, and chi square tests for categorical data.
**p* value <0.05 denotes statistical significance; †Kung Fu; ‡95% confidence interval; §Hedge's bias corrected effect size; ‖body mass index; ¶total body fat; ††lean body mass; ‡‡bone mineral density.

2006). Similarly, waist circumference growth charts show that abdominal obesity increases throughout childhood, even over six months (Eisenmann, 2005), but we again observed no significant increase in android fat mass or waist circumference over six months in our cohort. In fact, the TC group had a significant decrease in waist circumference of almost 3 cm, resulting in a between-group difference of 4.02 cm. This degree of change in waist circumference is comparable to diet and exercise studies over longer periods of time which have resulted in significant improvements in metabolic health in adolescents (Atlantis et al., 2006) and prevention of incident diabetes in high risk adults (Bo et al., 2007). Thus, our observations support an attenuation of expected increases in regional and total fat mass associated with study participation, although not preferentially in the KF group, as we had hypothesized.

Attenuation in fat gain might have been related to our subjects' participation in study exercise, and/or the (unprescribed) reduction in energy intake they reported (Table 2). Our data, however, did not support either of these possibilities. Specifically, neither attendance nor change in energy intake were significantly related to changes in total BF (attendance: r = 0.01, p = 0.96;

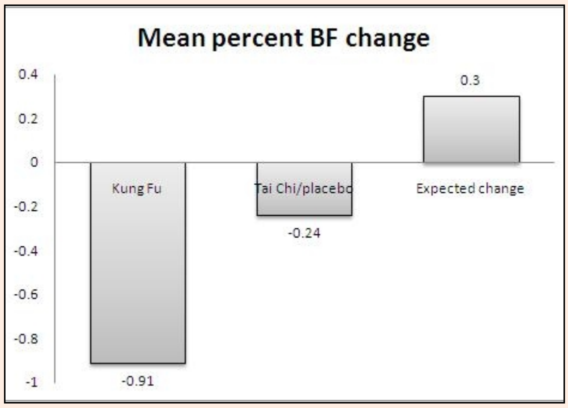

Figure 1. Illustration depicting changes in percent BF after six months, compared to expected growth-related changes (McCarthy et al., 2006). *P* values between groups were as follows: our cohort vs. growth chart = 0.09; Kung Fu vs. growth chart = 0.17; Tai Chi vs. growth chart = 0.35.

Table 2. Habitual physical activity and dietary intake. Values are mean (±SD), or median (range) for non-normally distributed data.

Characteristic	KF† Group Baseline n=12	KF† Group Follow-up n=11	Control Group Baseline n=8	Control Group Follow-up n=8	Mean difference (95% CI‡)	ES[g]	Time effect p	Group x time interaction p
Habitual physical activity								
MVPA‖	2.5 (1.9)	2.9 (1.7)	2.9 (1.9)	3.8 (1.3)	-.41 (-2.28–1.47)	-.20	.40	.63
Dietary intake								
Daily energy intake (kJ)	7148 (1882)	6715 (2167)	6045 (2357)	4558 (1823)	1053 (-1039–3144)	.48	.002*	.06
Daily energy intake ($kJ.kg^{-1}.d^{-1}$)	91.1 (37.9)	85.8 (45.8)	74.9 (44.6)	51.9 (18.7)	17.6 (-27.4– 62.6)	.41	.007*	.10
Total fat (g)	66.9 (21.2)	66.6 (29.0)	55.9 (23.5)	46.9 (23.3)	8.75 (-15.8–33.3)	.37	.07	.14
Saturated fat (g)	26.7 (7.5)	27.4 (10.3)	25.0 (11.4)	18.8 (9.4)	6.88 (-3.3–17.1)	.71	.07	.09
Polyunsaturated fat (g)	8.2 (2.8)	9.3 (4.7)	7.1 (2.7)	6.4 (4.4)	1.90 (-1.2 – 5.0)	.65	.94	.10
Monounsaturated fat (g)	24.9 (12.4–56.5)	22.6 (9.6–55.0)	18.6 (6.7–32.0)	17.8 (8.0–32.1)	-.54 (-11.9–10.8)	-.01	.03*	.35
Cholesterol (mg)	243 (127)	264 (78)	204 (119)	201 (160)	24.4 (-114.0–161)	.18	.54	.52
Protein (g)	57.4 (46.9–156.1)	73.5 (37.9–103.0)	59.2 (27.9–116.4)	54.2 (20.6–108.9)	3.09 (-31.82 – 38.01)	.37	.06	.20
Protein ($g.kg^{-1}.d^{-1}$)	.9 (.3)	.9 (.5)	.7 (.4)	.6 (.3)	.14 (-.25–.53)	.38	.11	.29
Carbohydrate (g)	194.8 (52.1)	173.9 (50.0)	167.8 (72.7)	107.8 (29.5)	39.1 (-28.4–106.5)	.61	.0008*	.04*
Sugars (g)	81.8 (34.2)	77.0 (35.2)	66.2 (36.2)	35.4 (11.0)	26.1 (-12.7-64.8)	.70	.01*	.04*
Sodium (mg)	2311 (1238–5393)	1881 (1120–3325)	1818 (915–3360)	1530 (850–3812)	-561 (-1678–556)	-.41	.02*	.67
kJ from protein (%)	16.8 (13.1–33.9)	18.7 (15.4–20.8)	19.4 (12.8–21.3)	20.3 (13.6–27.0)	-1.33 (-6.79–4.13)	-.08	.41	.74
kJ from fat (%)	34.6 (4.2)	36.4 (6.2)	33.6 (5.6)	37.3 (6.6)	-1.95 (-7.21–3.31)	-.39	.14	.80
kJ from carbohydrate (%)	47.2 (5.8)	45.4 (6.6)	48.1 (7.6)	42.5 (7.3)	3.85 (-3.36–11.06)	.56	.12	.42

P values were generated between treatment groups from independent t-tests for continuous data, and chi square tests for categorical data. **p* value of <0.05 denotes statistical significance; †KF Kung Fu; ‡95% confidence interval; §Hedge's bias corrected effect size; ‖moderate-to-vigorous physical activity (scores: 0 – 5, where a higher score reflects greater activity).

change energy intake: r = -0.41, p = 0.12), percent fat (attendance: r = -0.11, p = 0.65; change energy intake: r = -0.10, p = 0.72) or android fat mass (attendance: r = -0.08, p = 0.74; change energy intake: r = -0.32, p = 0.22).

Alternatively, increases in habitual physical activity levels or reductions in sedentary behaviour might have been etiological factors attenuating the increase in adiposity in our cohort. Unfortunately, although we planned to collect information on these important covariates objectively via accelerometry, subject non-compliance with this portion of the assessments resulted in too much missing data (only 6 subjects with pre-post accelerometry data) to allow adjustment for these factors in models of body fat outcomes.

Secondary outcomes and covariates

Body composition: Similar to expectations in this growing cohort, based on adolescent growth charts (available: http://www.cdc.gov/growthcharts/), our subjects had increased body weight (+3.74 ± 3.43 kg), height (+2.46 ± 1.97 cm), LBM (+2.38 ± 1.82 kg), arm LBM (+0.42 ± 0.51 kg), leg LBM (+0.68 ± 0.77 kg), and lumbar BMD [median change: +0.05 (-0.05 – 0.13 $g.cm^{-2}$)] after six months (Table 1). Notably, neither BMI nor BMI percentile changed despite the increased body mass, presumably as height increased as well (Table 1). There were no group differences in these body composition variables.

Habitual physical activity: Neither the time nor group effect for self-reported habitual physical activity levels (MVPA) were significant (Table 2). Regression analysis showed no relationship between change in MVPA and attendance (r = -0.003; p = 0.99).

Dietary intake: Absolute (-1283.2 ± 1713.7 kJ; p = 0.002) and relative daily energy intake (-19.7 ± 29.8 $kJ.kg^{-1}.d^{-1}$; p = 0.007) were reported to significantly decrease over time in both groups (Table 2). Significant reductions were also reported in reported intake of monounsaturated fat [median change: -2.5(-14.2 – 5.7)] g; p = 0.03), sugars (-20.6 ± 37.2 g; p = 0.01), sodium (median change: -288.4(-2068.4 – 647.2) mg; p = 0.02), and carbohydrates (-48.1 ± 56.5 mg; p = 0.0008) (Table 2). The TC group reported greater reduction in their intakes of energy (kJ), sugars, and carbohydrates than the KF group ($p < 0.05$). After adjusting for attendance, these group effects were strengthened, and a greater reduction in energy intake ($kJ.kg^{-1}.d^{-1}$) from the TC group approached significance also (p = 0.05). These results suggest that some feature of TC group participation led to general dietary intake restriction relative to the KF group. Unexpectedly, no dietary intake changes were related to body composition changes observed. However, it is acknowledged that well-known limitations of self-reported dietary intake in obese individuals and adolescents (Lichtman et al., 1992) may have attenuated any actual relationships that existed.

Attendance and compliance

Nineteen of the twenty (95%) subjects returned for follow-up assessments. One KF subject could not participate in follow-up testing as she had medical complications with Crohn's disease and was due to have surgery at that time.

Out of 72 offered classes, subjects attended 36.1 ± 14.8 (50.1 ± 20.6%) and 29.9 ± 26.7 (41.5 ± 37.1%) sessions in the KF and TC groups respectively (p = 0.51). After categorizing reasons for non-attendance into three categories, KF subjects were found to have missed more sessions due to unavoidable circumstances including injury/illness [KF: 12(4 – 23) vs. TC: 2.5(0 – 4); $p < 0.0001$]; or other reasons (including transport issues and vacations) (KF: 15.1 ± 9.3 vs. TC: 5.6 ± 4.0; p = 0.02); while more sessions were missed by TC subjects due to avoidable reasons of disinterest (including having other appointments of a non-medical nature, e.g., parties, and forgetting) (TC: 34.9 ± 29.7 vs. KF: 10.3 ± 16.1; p = 0.03).

All KF subjects who attended follow-up were satisfied with their six-month exercise program, while 50% of TC subjects were not satisfied with their program (chi square p = 0.008). Opinions on the session duration, frequency, ease of attending, and ease of following the instructor and performing the exercises did not differ between groups ($p > 0.05$).

Subjects who had to visit a health care professional more frequently had poorer attendance (r = -0.51; p = 0.02). Other predictors of attendance pertained to the attitudes of the subjects towards the exercise program, derived from the Patient Satisfaction Questionnaire. The subjects who had poorer attendance reported that the class frequency ($3x.wk^{-1}$) was too difficult for them (p = 0.0004), and tended to feel that the one-hour classes were too long (p = 0.054). Subjects who attended more classes reported feeling physically better after the training (p = 0.008), satisfied with the program (p = 0.007), and that they would recommend the program to others (p = 0.02). Feeling emotionally better after the training (p = 0.14), along with ease of following the instructors (p = 0.07), and performing the movements (p = 0.18) tended to improve attendance, although not significantly so in this small group. These results suggest that a variety of factors relating to subject characteristics and exercise delivery may influence adoption and adherence in this cohort. These factors include better health, more positive attitudes towards exercise, and positive physical and mental responses to actual training sessions.

Adverse events

Most adverse events reported by subjects were not related to study participation (99%). There were no significant differences between groups in adverse events, whether they were related to study participation [KF: 0(0 – 2) vs. TC: 0(0 – 0); p = 0.3, or not (KF: 13.9 ± 9.6 vs. TC: 7.1 ± 4.2; p = 0.08].

The study-related adverse events occurred to two KF subjects only, where both subjects fell (on separate occasions) during the jogging/star-jump-type exercise warm-up: one simply fell over during on-the-spot star-jump-type exercises, while the other was wearing inappropriate attire (stockings), and slipped on the carpet whilst jogging around the room. One of these two same subjects also reported knee pain during kicking practice. Only four sessions were missed as a result, by the subject who fell during the star-jump-type exercises, while the other adverse events did not result in any missed sessions. No other subjects experienced any adverse event related to their study participation.

In terms of non-study related adverse events, KF subjects reported more acute illness (KF: 6.3 ± 3.1 vs. TC: 2.8 ± 1.6; p = 0.009), although there were no significant differences between groups in reported injuries [KF: 4.0(0 – 18.0) vs. TC: 2.5(0 – 4.0); p = 0.10], new symptoms (KF: 3.4 ± 2.7 vs. TC: 2.5 ± 2.3; p = 0.44), or visits to health professionals (KF: 3.8 ± 3.4 vs. TC: 2.4 ± 2.1; p = 0.30).

Discussion

This was the first randomized placebo-controlled trial of isolated KF training on body composition in any cohort. We found that participation in a six-month, thrice weekly martial arts program comprised of either KF or the control martial arts condition (TC), appeared to attenuate the whole body and abdominal fat gain expected over six months in an overweight/obese cohort of this age (Eisenmann, 2005, McCarthy et al., 2006). The non-significant reduction in percent BF observed in our KF group after six months (-0.91±2.7%) was in fact greater than the statistically significant reductions reported by Benson et al [-0.3 ± 1.8% (Benson et al., 2008)] in a mixed weight adolescent cohort and Watts et al [-0.6% (Watts et al., 2004)] after eight-weeks of high-intensity resistance training or circuit-training respectively. By contrast, the five-month controlled-trial by Treuth et al (1998) noted a significant increase in fat mass after a thrice-weekly progressive resistance training program in obese pre-pubertal girls. Greater reductions in percent BF (-1.42 to -4.1%) have previously been observed in some trials using aerobic exercise interventions of shorter (up to four months) training durations in children or adolescents (Gutin et al., 1995; 1997; Ferguson et al., 1999; Owens et al., 1999). Thus, the literature is inconsistent regarding the efficacy and potency of isolated exercise interventions for body fat reduction in overweight adolescents. Our modest reduction in percent BF tended to be significantly less than our hypothesized changes (McCarthy et al., 2006), although without a non-exercising control group, no definitive conclusions can be drawn regarding the efficacy of our TC and KF programs for this outcome.

There are several reasons why our body fat changes may have been less than anticipated. First, although dietary intake was reported to decrease in both groups, subjects allocated to TC reported significantly more reduction in energy, carbohydrate, and sugar intakes relative to KF. This might be explained by TC subject non-compliance to trial requirements to maintain current dietary habits, or to the fact that KF participation, as a higher intensity activity resulting in greater energy expenditure per class (Jones and Unnithan, 1998; Ribeiro et al., 2006), might have increased appetite relative to TC participants. In most trials, untreated control subjects increased body fat over time, in contrast to the small reductions in body fat observed in our placebo-treatment controls. Thus, unintended selective contamination of controls with a dietary restriction co-intervention may have precluded us from identifying group differences.

Second, the energy expenditure of our active intervention may have been insufficient to induce an energy deficit and thus fat loss. Unlike previous trials which aimed to maintain a set intensity throughout their exercise sessions (Ferguson et al., 1999; Gutin et al., 1995; Owens et al., 1999; Watts et al., 2004), our KF sessions were relatively intermittent because the instructor regularly corrected, explained, and demonstrated techniques, rather than aiming to maximize energy expenditure. The intention of the trial was to try to replicate a general martial art class in an outpatient clinic setting, with the instructors directing the focus of activity more on technique performance and application, rather than exercise intensity/ energy expenditure, and the intensity of our program was not monitored. It is thus possible that the dose of exercise received by our subjects was less than in previous trials, and not enough to elicit body fat reductions of the same magnitude as previous aerobic and intensity-focused interventions. Recent trials comparing interval training and continuous training interventions have reported body fat reductions from both exercise interventions relative to non-exercising controls, with no difference between the exercise programs in the extent of improvements (Mosher et al., 2005; Tjønna et al., 2008). As our interventions were also intermittent in nature, this suggests that either our intervals of rest were too long, or the exercise intensity was too low overall, hence failing to produce an overall negative energy balance or enhance fat oxidation.

Third, compliance with our exercise sessions was low, with only about one-half of the intended sessions received, thus limiting potential for beneficial adaptations. Difficulties with retention in child weight management trials have previously been documented (Warren et al., 2007). In terms of dropout rates (those who were lost to follow-up), the dropout rate in this trial (5%) was far lower than that of other trials (6.3 – 52%) (Figueroa-Colon et al., 1998; Savoye et al., 2007; Warren et al., 2007). However, our adherence rate of 46.7% at six months was not favourable compared to previous studies, in which adherence rates at six months ranged from 74 – 81% (Savoye et al., 2007; Warren et al., 2007). Unlike some previous trials (Daley et al., 2006; Gutin et al., 1995; 1997; Owens et al., 1999; Warren et al., 2007), we had limited resources to offer many incentives to enhance adherence, which may in part explain the low attendance rates and compliance. In addition, we did not include a separate behavioural change strategy to address barriers to change, exercise self-efficacy, motivation, decisional balance, social support, outcome expectancy, etc., all of which have been suggested as important for lifestyle modification, including exercise adoption and adherence (Sallis et al., 2000; Uzark et al., 1988; Zabinski et al., 2003). We relied instead on provision of free access, and supervision, which have been shown to be successful in other cohorts (Treuth et al., 1998; Watts et al., 2004).

Dissatisfaction with the interventions may have contributed to the low compliance noted above, and undermined physiological adaptations. Most exercise sessions in our study (for the entire cohort) were missed due to “disinterest”, which included forgetting or refusing to attend, and double-booking other non-medically related appointments at session times. Other common reasons for missed sessions included lack of transportation, going away on holidays, and illness/injury. There were however, differences between the KF and TC groups in excuses for missed sessions. KF subjects missed more sessions due to unavoidable circumstances, whereas TC subjects used more avoidable circumstances as excuses, suggesting that KF subjects were more satisfied with their programs than TC subjects. Attendance seemed to be largely determined by attitude, such that those who thought the duration and frequency of the classes were too long or difficult attended fewer sessions. By contrast, subjects who reported satisfaction with the program, and feeling physically better after the program had higher attendance. In light of this, it would be worthwhile investigating this KF program further, so that for those who enjoy martial arts and choose to pursue the training, health benefits and enjoyment will be maximized.

Limitations of this trial were primarily related to the contamination of controls with their unintended dietary changes, the under-powering of the trial due to lower than anticipated recruitment rates, and the insufficient dose of the intervention in terms of both volume (due to low compliance) and intensity (due to session design and setting). Future trials on martial arts should send subjects to established training halls to train within standard classes, with experienced instructors (even if the other students within the class are not trial participants, nor are in the same age group). This would ensure the most generalisable training program, where the instructors are free to run classes as they usually would, in an appropriate environment, with the necessary equipment and uniforms. Being surrounded by more advanced pupils might also motivate subjects to train harder in such an environment, rather than in a hospital clinic with minimal space and equipment, surrounded by other novice study participants.

Based on our calculated ESs for our primary outcomes, our pilot study was under-powered for detecting significant changes in these outcomes. Future trials would need to recruit 1604 subjects and 872 subjects for detecting changes of the magnitude we observed in android fat mass and percent BF respectively, if alpha is set to 0.05 and power to 0.80. Although our pilot study was under-powered, this study has provided valuable information for the design and feasibility of martial arts trials for overweight/obese adolescent groups.

Conclusion

To our knowledge, this was the first clinical randomized, placebo-controlled trial of Kung Fu for health-related outcomes to be conducted in any cohort. It was performed in a hospital setting, examining overweight and obese adolescents from the general community, all of whom had one or more metabolic abnormalities placing them at risk for future cardiovascular disease already present on enrolment. Attenuation of expected gains in whole body and abdominal adiposity were observed in both KF and TC-controls over six months. Larger, longer-term studies will be required to determine whether the prevention of whole body and regional adipose tissue gain which we observed in this trial is a consistent finding, can be maintained or augmented over the long term, and whether metabolic benefits accrue from these body composition changes.

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Key points

- Participation in our martial arts trial attenuated the increases in body fat mass expected due to growth in our overweight/obese adolescent group.
- All subjects allocated to the Kung Fu intervention were satisfied with their Kung Fu training, in contrast to our placebo-exercise (Tai Chi) subjects, suggesting that this form of exercise is worth investigating further for adherence and efficacy.
- This was the first randomized, placebo-exercise controlled trial to be conducted, examining the effects of martial arts training alone on body composition in sedentary overweight/obese adolescents. Larger, longer-term trials are required to confirm our findings.

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