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Original Research

Effects of Synchronous and Asynchronous Music During High Intensity Training on Obesity and Metabolic Health in Singapore Women

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ABSTRACT

International Journal of Exercise Science 12(5): 1254-1264, 2019. Evidence suggests that high intensity exercise aided by music renders positive results in health related fitness components. However, less is known about the influence synchronous and asynchronous music may have on outcomes in overweight and obese women. A twelve-week, randomized-controlled trial was conducted using premenopausal overweight/obese (BMI > 24.9 kg/m^2) adult Singapore women (n = 92) divided into three groups (exercise with synchronous, asynchronous, and no music, respectively). Pre-post clinical examinations, anthropometric, and fitness evaluations were conducted. Statistical analyses revealed that physical activity was effective in all groups with music or non-music. Body composition, particularly weight loss and BMI, fitness, and metabolic parameters improved. Non-music and synchronous music were ergogenically effective for curl-up fitness. This multidisciplinary study demonstrated positive results for obesity reduction, fitness, and metabolic health. This transdisciplinary, Asia-Pacific-centric research is important in behavioural epidemiology framework because of its direct impact on population health.

KEY WORDS: Fitness, physical activity, weight loss, body composition

INTRODUCTION

Globesity has permeated Asia. Singapore, a developed nation in Southeast Asia with a high GDP-growth economy, is currently experiencing this predicament, as obesity in this country has risen consistently since 1998. The 2010 National Health Survey of Singapore (20), revealed an annual increase of 0.65% in the prevalence of obesity over the past six years, from 6% prevalence in 2004 to 10.8% in 2010 among Singapore adults aged 18 to 69 years. Singapore is affected by obesity's comorbidities, namely cancer, cardiovascular disease and diabetes mellitus, all of which rank among the top ten diseases affecting Singaporeans. This accounts for more than 60% of all deaths in Singapore.

According to The National Health Survey of 2010 and The Ministry of Health in Singapore (20), although Malays are a minority at 13.5% of Singapore's total population, this community has the highest obesity rate at 24%. Ai-Lien (5) reported that 7 in 10 Malays in Singapore were categorized as higher risk for obesity related co-morbidities as a result of their body compositions. Although physical activity is a commonly recognized modality to mitigate complications related to obesity, the levels of sports participation and exercise have declined (26). A 42% decrease in participation was reported across all participants under 60.

A dose-response relationship exists between the amount (frequency, intensity, duration) of physical activity and health outcomes (1). Based on the dose-response relationship of physical activity and health outcomes, physical activity at higher heart rates will generally lead to greater benefits (19). Higher heart rates are augmented by high intensity training consisting of the involvements of repeated short-to-long bouts of high-intensity exercise interspersed with passive or active recovery periods at a lower intensity. This type of training produces an optimal stimulus to elicit both maximal cardiovascular and peripheral adaptations where one spends several minutes per session in their 'red zone,' (namely, at least 90 % of their maximal oxygen uptake [VO_2 max]) (4). High intensity training prescriptions consist of the manipulation of nine variables: work interval intensity and duration, relief interval intensity and duration, exercise modality, number of repetitions, number of sets, as well as the between-set recovery duration and intensity. Manipulation of any of these variables can affect the acute physiological responses to high intensity training. The reason for using high intensity training in both healthy and clinical populations is that the vigorous activity promotes greater adaptations through increased cellular stress, while their short durations and ensuing recovery intervals allow even untrained individuals to work harder than what would otherwise be possible at steady-state intensity.

High intensity training has been shown to be safe for both the healthy and diseased populations (8,12). Studies on special populations, namely obese young females (22), chronic stroke survivors (9), and patients with cardiovascular and metabolic disease (24) supported this.

To address the reduced functional capacity of our sample (11), music was used as an ergogenic aid in this research. Music assists in exercise performance by reducing the sensations of fatigue, promoting relaxation, increasing physiological arousal and improving motor coordination (28). Karageorghis and colleagues' (16) research on synchronous and asynchronous music reported that women gained greater benefits from both music conditions ergogenically and psychologically during circuit type exercise compared to men. This knowledge that women gained greater benefits from both music conditions is the focus of this research.

Previous studies have been conducted to test the effectiveness of synchronous and asynchronous music in treadmill walking (15), cycle ergometry (2), 400-m running (25), and swimming (14). However, the effects of culture-centric synchronous and asynchronous music have not been researched among overweight and obese Singapore Malay women.

METHODS

Participants

Ninety-two overweight and obese Singaporean adult women were recruited voluntarily for this twelve-week randomized controlled trial. Subjects were randomly allocated into two treatment groups (exercise with synchronous music [n = 31] and exercise with asynchronous music [n = 31]) and a control group (exercise with no music [n = 30]). Subjects were 43 ± 9.0 yrs (Group A = exercise with synchronous music), 40 ± 10.7 yrs (Group B = exercise with asynchronous music) and 40 ± 9.4 yrs (Group C = exercise without music), respectively. 29.3% of the subjects were ≤ 34 years old, 28.3% were in the range of 35 to 44 years old, while the rest were ≥ 45 years old (42.4%).

Protocol

Having provided written informed consent, subjects obtained medical clearance prior to the study via clinical examination. The examination was done by a certified physician in Singapore, and consisted of serum lipid analysis (total cholesterol, HDL cholesterol, LDL cholesterol, total/HDL ratio), resting heart rate, blood glucose, systolic and diastolic blood pressure. This same clinical examination was conducted following the twelve-week intervention. Fitness evaluations, specifically push up, curl up, and bodyweight squat tests, were also conducted at baseline and post intervention. Subjects were advised to keep to their usual food intake with no caloric restriction.

Pre- and post-anthropometric evaluations were also conducted on all subjects. Height and body weight were measured to the nearest 0.1 cm and 0.1 kg, respectively. Girth measurements for chest, abdomen, waist, and hip were taken to the nearest 0.1 cm using Myotape (AccuFitness LLC, USA). Body mass index (BMI) and waist-to-hip ratio was calculated. Skinfolds for triceps, abdomen, and suprailiac were taken using calipers and fat percentage was calculated using the Jackson & Pollock equations (13).

A guided thrice weekly physical exercise training program was used as the intervention. Dynamic warm up was utilized as opposed to static stretching warm up because of its effects on power and agility (18). Following the dynamic warm up, the intervention consisted of intervals of bodyweight exercise, which included modified pushups, modified curl ups, and bodyweight squats. Subjects concluded with a dynamic cool down and static stretches. The intervals of the bodyweight movements were executed in three sets of 12, 9, and 6 repetitions, respectively, with 90 seconds of rest in between the sets. Midway through the twelve week intervention, the rest interval was shortened to 30 seconds between sets. Stretches were incorporated for the quadriceps, adductors, hamstrings, tibialis anterior, gastrocnemius and soleus, obliques, latissimus dorsi, pectorals, deltoids, biceps, triceps, and sternocledomastoid.

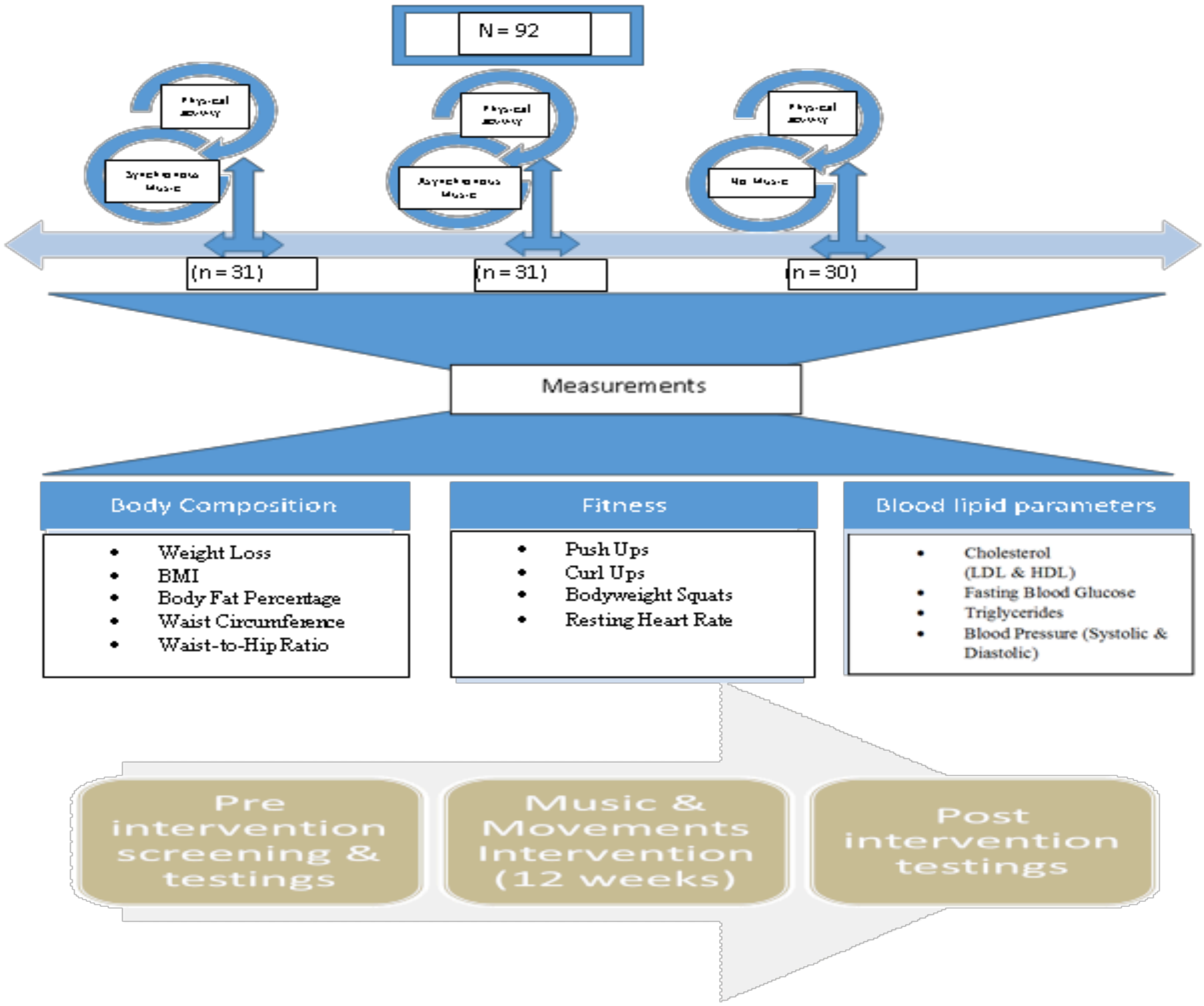

Figure 1. High intensity training & music on body composition, fitness and metabolic health

Statistical Analysis

Data were analyzed using SPSS (Statistical Package for the Social Science). All descriptive data were expressed as mean ± standard deviation. A paired sample t-test was first conducted to determine any changes before and after interventions. Further, a split-plot ANOVA (SPANOVA) was carried out to explore intervention between groups (Group A = exercise with synchronous music; Group B = exercise with asynchronous music; Group C = exercise with no music) for body composition, blood lipid metabolic profiles, and fitness at Time 1 (baseline, prior to intervention) and Time 2 (12-weeks after intervention). Statistical significance was accepted at $p<0.05$ for all tests.

RESULTS

Results from this study are displayed in Table 1. There were significant decreases ($p<0.01$) in all variables except for waist-to-hip ratio, where the changes were not significant ($t = -1.15$, $t = -1.00$ and $t = -0.55$ for Group A, Group B, and Group C, respectively).

Table 1. Paired sample t-test results of body composition pre and post-training for high intensity exercise with synchronous, asynchronous and without music

Body composition	Group A (exercise with synchronous music)				Group B (exercise with asynchronous music)				Group C (exercise without music)			
	Pre (Mean ±SD)	Post (Mean ±SD)	Paired diff	t	Pre (Mean ±SD)	Post (Mean ±SD)	Paired diff	t	Pre (Mean ±SD)	Post (Mean ±SD)	Paired diff	t
Weight (kg)	78.1 ±14.6	71.5 ±11.7	6.64 ±4.49	8.23 **	76.7 ±10.4	73.2 ±10.7	3.55 ±3.57	5.54 **	80.8 ±10.5	77.1 ±9.9	3.69 ±2.71	7.45 **
BMI (kg/m²)	31.3 ±5.1	28.7 ±4.2	2.63 ±1.66	8.84 **	31.1 ±4.0	29.7 ±4.1	1.44 ±1.47	5.48 **	32.5 ±4.4	31.0 ±4.1	1.48 ±1.10	7.39 **
Chest girth (in)	38.7 ±3.0	36.3 ±2.9	2.44 ±2.11	6.42 **	39.1 ±3.3	37.1 ±3.0	1.98 ±2.01	5.50 **	39.4 ±3.3	37.4 ±3.6	1.92 ±1.82	5.78 **
Abdomen girth (in)	38.2 ±4.3	35.1 ±3.2	3.11 ±2.97	5.84 **	38.8 ±3.7	36.2 ±3.7	2.61 ±3.13	4.65 **	39.8 ±3.5	37.5 ±3.5	2.31 ±2.21	5.73 **
Waist girth (in)	36.0 ±4.2	33.6 ±3.0	2.42 ±2.18	6.17 **	36.6 ±3.6	34.5 ±3.2	2.11 ±2.21	5.34 **	37.0 ±2.6	35.0 ±2.4	2.02 ±2.02	5.47 **
Hip girth (in)	43.3 ±3.6	40.0 ±3.6	3.26 ±3.01	6.04 **	43.4 ±3.5	40.6 ±2.9	2.81 ±2.72	5.75 **	45.1 ±3.2	42.5 ±4.0	2.60 ±2.16	6.60 **
Waist-to-hip ratio	0.83 ±0.06	0.84 ±0.07	-0.01 ±0.05	-1.15 n.s.	0.84 ±0.05	0.85 ±0.06	-0.01 ±0.04	-1.00 n.s.	0.82 ±0.05	0.83 ±0.05	-0.05 ±0.05	-0.55 n.s.
Triceps fat (%)	28.0 ±8.0	21.2 ±3.6	6.77 ±7.47	5.05 **	29.1 ±5.9	24.3 ±4.6	4.76 ±4.85	5.46 **	30.6 ±5.4	26.4 ±5.9	4.22 ±3.88	5.95 **
Thigh fat (%)	41.7 ±12.1	29.8 ±8.8	11.92 ±11.42	5.81 **	43.5 ±8.6	33.8 ±8.8	9.69 ±9.86	5.48 **	44.0 ±11.7	36.8 ±12.3	7.22 ±7.19	5.50 **
Suprailium fat (%)	25.9 ±10.4	18.0 ±6.5	7.89 ±10.07	4.36 **	27.7 ±7.7	21.2 ±6.1	6.53 ±7.47	4.87 **	28.7 ±10.1	23.5 ±8.6	5.15 ±5.77	4.89 **
Body fat sum	95.6 ±27.1	69.0 ±16.4	26.58 ±25.75	5.75 **	100.3 ±18.2	79.3 ±17.5	20.98 ±18.55	6.30 **	103.3 ±25.4	86.7 ±25.0	16.59 ±15.19	5.98 **

Data are presented as the mean value ± standard deviation; ** $p< 0.01$; n.s. non-significant.

Group A (exercise with synchronous music) showed the largest paired difference in their body composition, while Group B (exercise with asynchronous music) and Group C (exercise with no music) revealed similar changes for the variables tested. However, interestingly, SPANOVA analysis showed that the interaction effect was not statistically significant (Wilk's lambda = 0.338), indicating there was no difference in body composition for the three groups pre- and post-intervention. Our results were in agreement with that of Slentz and colleagues' (21), who also reported that physical activity is associated with significant reductions in body weight and fat mass in overweight and obese middle aged men and women in a dose-response manner.

All subjects were overweight (46.7%) or obese (53.3%) before the intervention, with 5.4% of the subjects in Grade III obesity (BMI > 40.0). At the start of the study, none were in the healthy range. Post intervention, subjects improved enough to move into the healthy range at 19.35%, 9.67%, and 3.33% respectively, across the three groups. However, subjects were still in increased risk and high risk according to the Asian BMI cut-off points. Physical activity is inversely associated with body weight, thus associated with lower BMI in adults (27). This study showed that increasing physical activities resulted in clinically significant weight loss of more than 5% even without caloric restriction (3).

Changes in push up, curl up, and bodyweight squat fitness tests were statistically significant ($p<0.01$). The percentage of subjects that fell into the very poor norm category was reduced drastically in the push up test (16.3% to 1.1%), curl up test (90.2% to 29.3%), and bodyweight squat test (33.7% to 3.3%), respectively. The study's twelve week duration indicates that the increases in muscular strength for this study are not just due to neural adaptations or to increased motor unit recruitment. The study's twelve week duration demonstrated that, collectively, the learned recruitment of additional motor units, the increased activation of synergistic muscles, and the inhibition of neural protective mechanisms (21), all contributed to enhance the muscle's ability to generate more force, thus the improvement of strength in the push up, curl up, and bodyweight squat results post intervention.

Table 2. Changes in physical fitness pre- and post-training.

Fitness tests	Paired differences			t			Sig.		
	Group A	Group B	Group C	Group A	Group B	Group C	Group A	Group B	Group C
Push up	-12.94±7.13	-9.90±5.46	-8.13±5.93	-10.11	-10.11	-7.51	**	**	**
Curl up	-17.03±7.71	-10.13±7.17	-9.93±6.98	-12.31	-7.86	-7.33	**	**	**
Bodyweight squat	-26.55±11.83	-20.13±22.66	-12.63±9.46	-12.49	-4.95	-7.32	**	**	**

Data were presented as the mean value ± standard deviation; ** $p < 0.01$.

A comparison between pre- and post-intervention in all three groups revealed significant differences in the metabolic profiles except for total cholesterol / HDL ratio and blood glucose. SPANOVA analysis showed that the main effect between groups of intervention on blood lipid metabolic profile was 0.506 [$F(18,86) = 1.938$, $p = 0.023$], showing that group effect is statistically significant, with a large effect size (partial eta squared = 0.289). Yet, a further post-hoc comparison using Tukey HSD test indicated that the mean for the three intervention groups did not differ significantly from each other.

Table 3. Effect of intervention on blood chemistry and hemodynamic variables.

Metabolic profiles	Paired differences			t			Sig.		
	Group A	Group B	Group C	Group A	Group B	Group C	Group A	Group B	Group C
Systolic BP	5.25±10.23	5.24±10.92	-0.46±16.80	2.716	1.977	-0.090	**	n.s.	n.s.
Diastolic BP	8.68±10.85	7.94±9.91	1.91±11.27	4.234	3.304	0.562	**	**	n.s.
Resting heart rate	4.75±6.36	1.65±3.97	7.50±8.71	3.954	1.712	2.724	**	n.s.	*
Total cholesterol	25.82±29.46	9.59±23.62	12.40±15.72	4.638	1.674	2.494	**	n.s.	*
HDL-cholesterol	6.00±7.59	4.18±6.87	0.40±9.51	4.182	2.508	0.133	**	*	n.s.
Total cholesterol/ HDL ratio	0.64±0.53	-0.10±0.60	0.13±0.60	0.644	-0.690	0.683	n.s.	n.s.	n.s.
LDL-cholesterol	15.21±25.65	1.82±19.75	6.90±20.80	3.138	0.381	1.049	**	n.s.	n.s.
Triglyceride	23.79±35.06	17.41±66.23	30.90±17.03	3.590	1.084	5.737	**	n.s.	**
Blood glucose	3.37±13.09	-0.12±11.67	8.40±27.06	1.338	-0.042	0.982	n.s.	n.s.	n.s.

Data were presented as the mean value ± standard deviation; * $p < 0.05$; ** $p < 0.01$; n.s. non-significant.

Regarding weight reduction, for Group A exercise with synchronous music, a significant regression equation was found $F(1,10)=1273.627$, p=0.00, with an R^2 of 0.992. Participants' predicted weight is equal to 78.947 + (-0.637) (time) (unit of weight) when time is measured in weeks. Participants' waist decreased -0.637 for each week of time.

The prediction formula for weight loss in the first treatment of synchronous music to exercise: $y\_G1 = -0.637x + 78.947$; $R^2 = 0.992$.
This means that 99.2% of the variance y_G1 is predicted by the formula. This finding can be used as a benchmark for predicting weight reduction improvements in obese adult.

For Group B exercise with asynchronous music, a significant regression equation was found $F(1,10)=1178.619$, p=0.00, with an R^2 of 0.992. Participants' predicted weight is equal to 77.376 + (-0.359) (time) (unit of weight) when time is measured in week. Participants' weight decreased -0.359 for each week of time.

The prediction formula for weight loss in the second treatment group of asynchronous music to exercise: $y\_G1 = -0.359x + 77.376$; $R^2= 0.992$.

This means that 99.2% of the variance y_G1 is predicted by the formula. This finding can be used as a benchmark for predicting weight reduction improvements in obese adult Singapore Malay women when they exercise to asynchronous music.

For Group C exercise with no music, a significant regression equation was found $F(1,10)=8340.330$, $p=0.00$, with an R^2 of 0.999. Participants' predicted weight is equal to 81.182 + (-0.343) (time) (unit of weight) when time is measured in week. Participants' waist decreased -0.343 for each week of time.

The prediction formula for weight loss in the control group of no music to exercise: $y\_G1 = -0.343x + 81.182$; $R^2 = 0.999$.

This means that 99.9% of the variance y_G1 is predicted by the formula. This finding can be used as a benchmark for predicting weight loss in obese adult Singapore Malay women when they exercise to no music.

DISCUSSION

De Feo (6) reported that although there is attraction to executing exercises in shorter time, and that high intensity training appears to induce superior improvements in fitness, prescribing a higher-intensity exercise for obese individuals decreases adherence to exercise due to the discomfort and potential injuries. De Feo (6) further added that a successful exercise program should be proposed at a moderate intensity and a low perceived effort because obese subjects who have low self-efficacy, poor mood status, and are not familiar with high-intensity workouts could easily drop out. It has been reported otherwise in this study.

Exercise participation adherence was high with an attendance level of 90%. Subjects' absent days were due to family commitments or holidays. Only one subject dropped out due to family commitments. Findings in this study points towards Heinrich and colleagues' study (10) examining high intensity functional training among physically inactive overweight and obese adults, which was compared to moderate-intensity training for exercise initiation, enjoyment, adherence, and intentions. Their study reported they maintained exercise enjoyment and were more likely to continue. Our study attended to the commonly cited barriers to regular exercise participation for the obese, such as "lack of time" and "boredom of exercise" as cited by Egan and colleagues (7). High intensity exercises in this study were conducted with adequate warm up and cool downs. There were no injuries reported throughout the study, further supporting the safety of high intensity exercise for the obese.

La Vie's obesity paradox (17) has documented several trials of overweight and obese individuals with established cardiovascular disease (including cardiac heart disease, heart failure, hypertension, and peripheral artery disease) having a better prognosis compared with non-overweight/non-obese patients, where fitness in fatness becomes a protective quality. The fitness in fatness is applicable here. By propagating fitness in fatness and fitness against fatness in this obesity fitness management program, the end result will be a reduction of weight, but more applicably fat loss, as well as disease pre-cursor prevention, management, and treatment. An emphasis on fitness and health as opposed to weight loss versus fat loss must be enhanced in all community obesity management programs.

Physical activity produces many beneficial health outcomes that are too often deemphasized in favour of weight-based end points, which is also reiterated by Shaibi and colleagues (23). Exercise training improves insulin resistance, beta cell function, glucose tolerance, dyslipidemia, vascular function, strength, fitness, and functionality. More effort should be made to educate the public and shift the emphasis on fitness management in obesity programs. Findings from this study show that physical activity intervention is effective for obesity fitness management in all groups. Music is less effective in this study as a disassociation tool at high exercise intensities owing to the pre-eminence of physiological cues. Further research is recommended on music as an ergogenic aid and its impact on high intensity exercise.

An inclusive, social community initiative in terms of a holistic prevention and solution must be championed to target the disability-free, quality driven lifestyle of a healthy weight. It is proposed that obesity fitness management should be more group-centric than individual-centric. This study brought it a step further by making it culture-centric with the inclusion of culture-centric music. This goes towards the change of societal norms in terms of physical activity than to deal only with the individuals who suffer from the detrimental effects of inactivity. Population-based approaches are sought positively to affect the outcome of physical activity against obesity.

This study has a direct impact on public health. As similar studies in Asia Pacific are rather limited at the moment, this is imperative towards knowledge in obesity fitness management in progressively urban Asia. This research is important not only in Singapore's context, but also in the other Southeast Asian countries riding its globalization wave. Its findings are applicable as an obesity fitness management tool targeting the dynamics of a community intervention. As Southeast Asia becomes progressively urbanized, the results of this research are valuable, not only as a case study in a developed nation's fight against obesity, but can be used as translational to achieve the recommended BMI in the developing countries of Southeast Asia.

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