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A structured lifestyle intervention combined with mobile health application to reduce chronic disease risk among employees at a university workplace

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Abstract

Introduction: This pilot study assessed the impact of a structured lifestyle intervention combined with mobile health application on chronic disease risk in a healthcare-based university.

Methods: A total of 24 overweight/obese university employees participated in a 12-week intervention that included group nutrition education and exercise sessions, a structured low-calorie meal plan, meal replacements, and a mobile health application.

Results: A pre- and post-intervention analysis showed that the participants had weight loss ($p < 0.001$), a reduction in blood triglyceride ($p = 0.010$), and a reduction in systolic blood pressure ($p < 0.001$). There was an increase in the proportion of participants who achieved their clinical targets for systolic blood pressure from 16.7% at baseline to 58.3% after the intervention ($p = 0.004$). A focus group discussion demonstrated good acceptability of the intervention that was driven by the use of practical nutrition knowledge gained from the group education sessions and structured meal plans, and timely feedback on eating behaviour from use of the mobile heath application.

Conclusion: A structured lifestyle intervention combined with mobile health application supports significant clinical improvements including weight loss and reductions in blood triglyceride and blood pressure.

Keywords: *Chronic diesease, Mobile health, Obesity, Structured lifestyle intervention, Workplace wellness*

Introduction

Globally, the greatest cumulative impact on health are metabolic risks driven by high Body Mass Index (BMI), blood sugar, blood pressure, and cholesterol.[1] In the Malaysian workforce, the prevalence of adults living with either high blood sugar, blood pressure or cholesterol range from 12.7% to 42.9%.[2] This population also follows an unhealthy diet, a behavior that propels the progression of these chronic conditions.[2]

The workplace is a priority setting for health promotion.[3] Well-designed and well-executed workplace wellness programs can improve health scores, generate cost savings, and retard the growth in total medical expenditures of workplaces.[3,4] Nonetheless, the key issues when implementing a workplace wellness program include engagement of stakeholders, employee participation, judicious use of resources, and the effects of the program on clinical outcomes.[5-7] A promising solution to this conundrum is the use of multi-disciplinary collaboration to incorporate lifestyle interventions tailored to individual behaviour within a workplace wellness program.[8-10] Mobile health applications can also be used to improve employee participation in workplace wellness programs. However, this strategy has been limited to self-monitoring activities, with a decline in technology use and engagement observed over time.[11,12] Addressing antecedents such as perceived usefulness, ease of use, enjoyment, and cues to action when designing the application, can increase motivation to use mobile health applications.[13]

Existing workplace wellness programs in Malaysia do not offer a combination of a lifestyle intervention and mobile health application. Hence, this pilot study assessed the impact of a 12-week structured lifestyle intervention combined with a mobile health application with a function that cues self-monitoring of behaviour, on chronic disease risk in a healthcare-based university.

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Methods

Study design

This study utilised a pre- and post-test design whereby the participants were measured at baseline and at the end of a 12-week workplace wellness program – IMUHEALxNaluri. The IMUHEALxNaluri is a structured lifestyle intervention program designed to manage chronic disease risk. This program incorporated the use of group education sessions, structured meal plan, meal replacements, and a mobile health application.

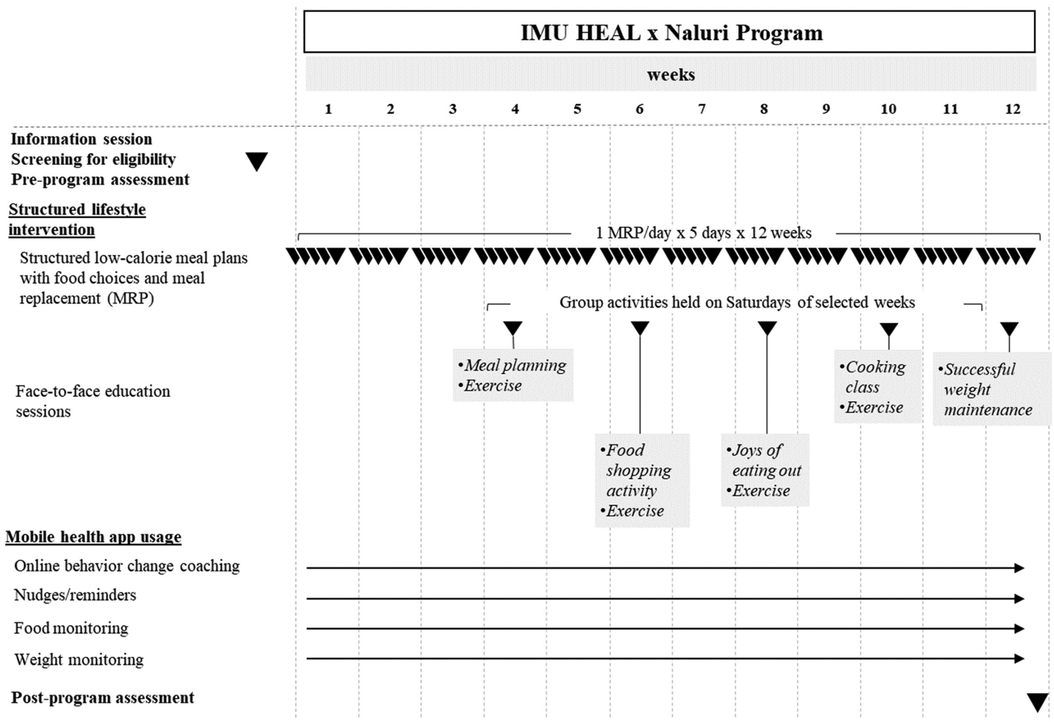
Participants

Employees of the International Medical University (IMU) in Kuala Lumpur, Malaysia were invited to participate in IMUHEALxNaluri through email and during a health screening event. A minimum of 30 participants were targetted for this pilot study to detect weight change at a moderate to large effect size.[14] Subsequently, the interested employees were screened for eligibility. A health assessment identified participant eligibility based on presence of overweight and obesity at BMI > 23 kg/m^2 due to higher risk of chronic diseases at BMIs lower than 25kg/m^2 in the Asian population.[15] The exclusion criteria were pregnancy and lactation. Approval to conduct the study was given by the ethics committee of IMU (Project number: R454/2019). Informed consent was obtained using a mobile health application.

Intervention

Five group nutrition education sessions led by dietitians were held once every two weeks. The group nutrition education sessions were complemented with group exercise sessions lasting between 30 to 45 minutes each. A structured meal plan was provided at baseline to keep daily calorie intake within 1200 - 1500 kcal. The meal plan was an illustrated booklet containing 155 Asian food and beverage choices that were color-coded for calorie, fat, sugar and salt content. The use of meal replacements was available as a portion control strategy. Figure I shows the components of the IMUHEALxNaluri program.

Figure I: Components of the IMUHEALxNaluri workplace wellness program



Throughout the study, the participants used a mobile health application based on cognitive behavior therapy and motivational interviewing approaches to support behavior change. Nudges were sent from the mobile application to encourage the participants to self-monitor their diet and weight. The participants uploaded photographs of their food intake for feedback from a dietitian via the application. The participants also weighed themselves at home using a digital weighing scale that was connected to the mobile application. After the 12-week intervention, the participants were given the option to attend individual consultations with a dietitian at the IMU Healthcare Clinic to support weight maintenance.

Data collection and processing

The outcomes of interest were collected at baseline and at the end of the 12-week intervention. Sociodemographic information and medical history – including self-reported presence of obesity related co-morbidities, were assessed using a questionnaire. Standing body weight and height was measured using a digital weighing scale with an attached rod (Tanita WB-800H). BMI was calculated as a ratio of the measured body weight to height. Venous blood samples were analyzed for HbA1c and lipid profile using a fully automated analyzer at a commercial diagnostics laboratory (Roche Cobas® 8000). Blood pressure was measured with a fully automated blood pressure monitor (Omron HEM-907, Omron, Japan). Depression, anxiety, and stress levels were measured using the Depression, Anxiety and Stress Scale (DASS-21) that was embedded in the mobile health application. The proportion of participants achieving clinically significant improvement was defined for each risk factor based on the following targets: HbA1c < 5.6%; Total cholesterol ≤ 5.2 mmol/L; LDL-cholesterol < 3.0 mmol/L; HDL-cholesterol ≥ 1.0 mmol/L for men and ≥ 1.2 mmol/L for women; Triglyceride ≤ 1.7 mmol/L; Systolic blood pressure < 120 mmHg; and Diastolic blood pressure < 80 mmHg.

Employee participation was assessed using an attendance log captured at the start of each group education session. The participants also provided self-reported frequencies of meal-replacement and mobile application use at the end of the intervention. Additionally, three focus group discussions were conducted at the end of the intervention to explore relevance and acceptability of the intervention. Each focus group met once. The 30 – 45 minute discussions were facilitated by two researchers who used a discussion guide. The discussion guide covered five areas: difference between current and previous lifestyle change attempts; strategies for lifestyle change learned from the intervention; successes and difficulties faced during the intervention; and lifestyle changes made because of the intervention. Each discussion was audio-recorded, transcribed verbatim, and coded for thematic analysis.

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 23.0). Body weight, HbA1c, lipid profile, blood pressure, and mental health status scores (depression, anxiety, and stress) were analysed on a pre- and post-intervention basis using the Wilcoxon signed-rank test and effect size calculated using strength of association, r[16]. The proportion of participants who achieved their clinical targets were analyzed using the exact McNemar's test. Further analysis was conducted by segregating the data into upper and lower 50th percentiles of weight change to determine if changes in HbA1c, lipid profile, blood pressure, and mental

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health status scores might result from weight change. The difference in health changes between the upper and lower 50th percentiles of weight change were analyzed using the Mann-Whitney test. Statistical significance was set at $p < 0.05$.

Results

Of the 30 adults who provided consent, a total of 24 participants completed the program (Figure II). The study participants had a median (IQR) age of 35.5 (9.0) years, and more than half were women and of the Malay ethnic background. Using Asian-specific BMI thresholds, 87.5% of the participants (n = 21) had obesity or a BMI > 27. Baseline characteristic in the upper and lower 50th percentiles of weight loss was evenly distributed with respect to age. The median body weight and BMI were higher in the upper versus lower 50th percentile of weight loss. When compared to the lower 50th percentile of weight loss, the upper 50th percentile of weight loss had more participants who were men, Malay, and with diabetes and hypertension (Table I).

Figure II: Flow of participants through the program

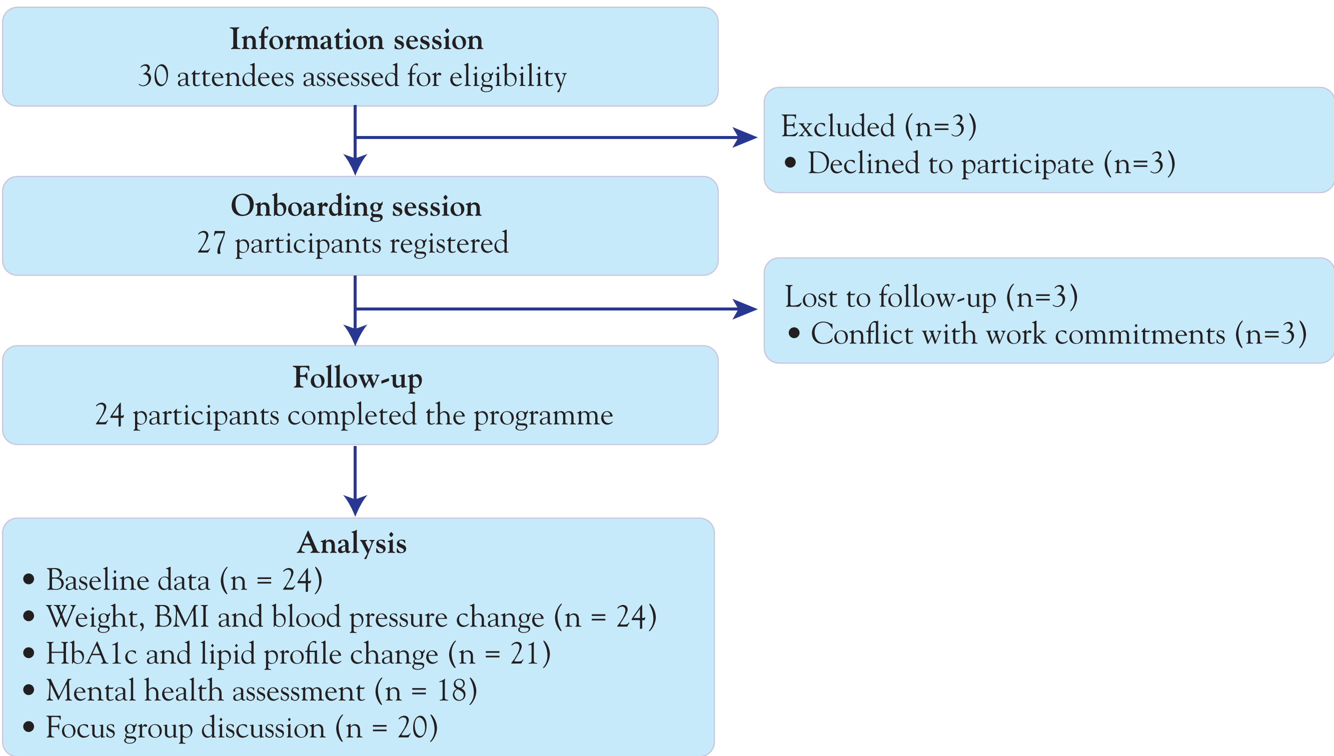


Table I: Baseline characteristics of the study participants (N=24)

Characteristics	Upper 50th Percentile -10.7kg to -2.4kg (n=12)	Lower 50th Percentile -2.4kg to +1.9kg (n=12)	Total (N=24)
Age (years) †	35.5 (8.0)	35.5 (12.0)	35.5 (9.0)
Gender‡			
Men	5 (41.7)	3 (25.0)	8 (33.3)
Women	7 (58.3)	9 (75.0)	16 (66.7)
Ethnicity‡			
Malay	9 (75.0)	6 (50.0)	15 (62.5)
Chinese	1 (8.3)	2 (16.7)	3 (12.5)
Indian	2 (16.7)	4 (33.3)	6 (25.0)
Weight (kg)†	84.2 (17.2)	73.0 (27.5)	79.4 (21.0)
BMI (kg/m^2)†	31.6 (8.0)	30.1 (5.1)	31.2 (6.8)
Presence of co-morbidities ‡			
Diabetes	2 (16.7)	1 (8.3)	3 (12.5)
Hypercholesterolaemia	3 (25.0)	3 (25.0)	6 (25.0)
Hypertension	7 (58.3)	3 (25.0)	10 (41.7)

† Data for age, weight and BMI are median (IQR)s

‡ Data for gender, ethnicity, and presence of obesity related co-morbidities are n (%)

Pre- and post-program health outcomes

Participating in the wellness program elicited a statistically significant difference in body weight ($p < 0.001$) and BMI ($p < 0.001$) (Table II). Median (IQR) body weight decreased from 79.4 (21.0) kg to 74.3 (20.3) kg, while median (IQR) BMI decreased from 31.2 (6.8) kg/m^2 to 30.4 (6.8) kg/m^2, after 12-weeks of intervention. The differences seen in weight and BMI were of a large effect size.

Of the participants who completed the intervention, three were excluded from analysis of HbA1c and lipid profile because of failure to find an appropriate vein for the blood collection. After the wellness program, the participants had a statistically significant increase in HbA1c ($p = 0.011$), but the increase was not clinically relevant. The intervention also produced an increase in LDL-cholesterol ($p = 0.001$) and HDL-cholesterol ($p = 0.017$), and a decrease in blood triglycerides ($p = 0.010$). Participating in the wellness program produced a statistically significant difference in systolic blood pressure ($p < 0.001$) with a median (IQR) systolic blood pressure that dropped from 131.5 (19.0) mmHg to 117.5 (25.3) mmHg. The difference seen in blood pressure before and after the intervention was of a large effect size. An exact McNemar's test showed a statistically significant increase in the proportion of participants who achieved their clinical targets for systolic blood pressure from 16.7% (n = 4) at baseline to 58.3% (n = 14) after the wellness program ($p = 0.004$).

Of the participants who completed the intervention, six participants did not complete the mental health assessment as the application did not fully load on their smartphones. Median (IQR) depression, anxiety and stress scores decreased after the wellness program, but this trend was not statistically significant.

Table II: Body weight status, glycaemic control, lipid profile, blood pressure and mental health status before and after the intervention

Study outcomes	Baseline	12-weeks	Effect size (r)	p-value
Body weight status† (n=24)				
Weight (kg)**	79.4 (21.0)	74.3 (20.3)	0.56	< 0.001±
Body Mass Index (kg/m^2)**	31.2 (6.8)	30.4 (6.8)	0.51	< 0.001±
Glycaemic control† (n=21)				
HbA1c (%)*	5.4 (0.5)	5.5 (0.5)	0.39	0.011±
Lipid profile† (n=21)				
Total cholesterol (mmol/L)**	4.8 (1.0)	5.1 (1.1)	0.41	0.009±
LDL-cholesterol (mmol/L)**	2.58 (0.80)	2.97 (1.1)	0.53	0.001±
HDL-cholesterol (mmol/L)*	1.17 (0.39)	1.25 (0.47)	0.37	0.017±
Triglycerides (mmol/L)*	2.1 (1.6)	1.7 (1.5)	0.40	0.010±
Blood pressure† (n=24)				
Systolic blood pressure (mmHg)**	131.5 (19.0)	117.5 (25.3)	0.52	< 0.001±
Diastolic blood pressure (mmHg)	84.5 (15.8)	78.5 (16.8)	0.11	0.466±
Mental health status† (n=18)				
Depression score (points)	4.0 (7.0)	2.0 (5.0)	0.26	0.104±
Anxiety score (points)	5.0 (7.0)	4.0 (6.0)	0.26	0.096±
Stress score (points)	9.0 (10.0)	7.0 (11.0)	0.29	0.065±

† Data for body weight status, HbA1c, lipid profile, blood pressure, and mental health status are median (IQR)s

± Wilcoxon signed-rank test

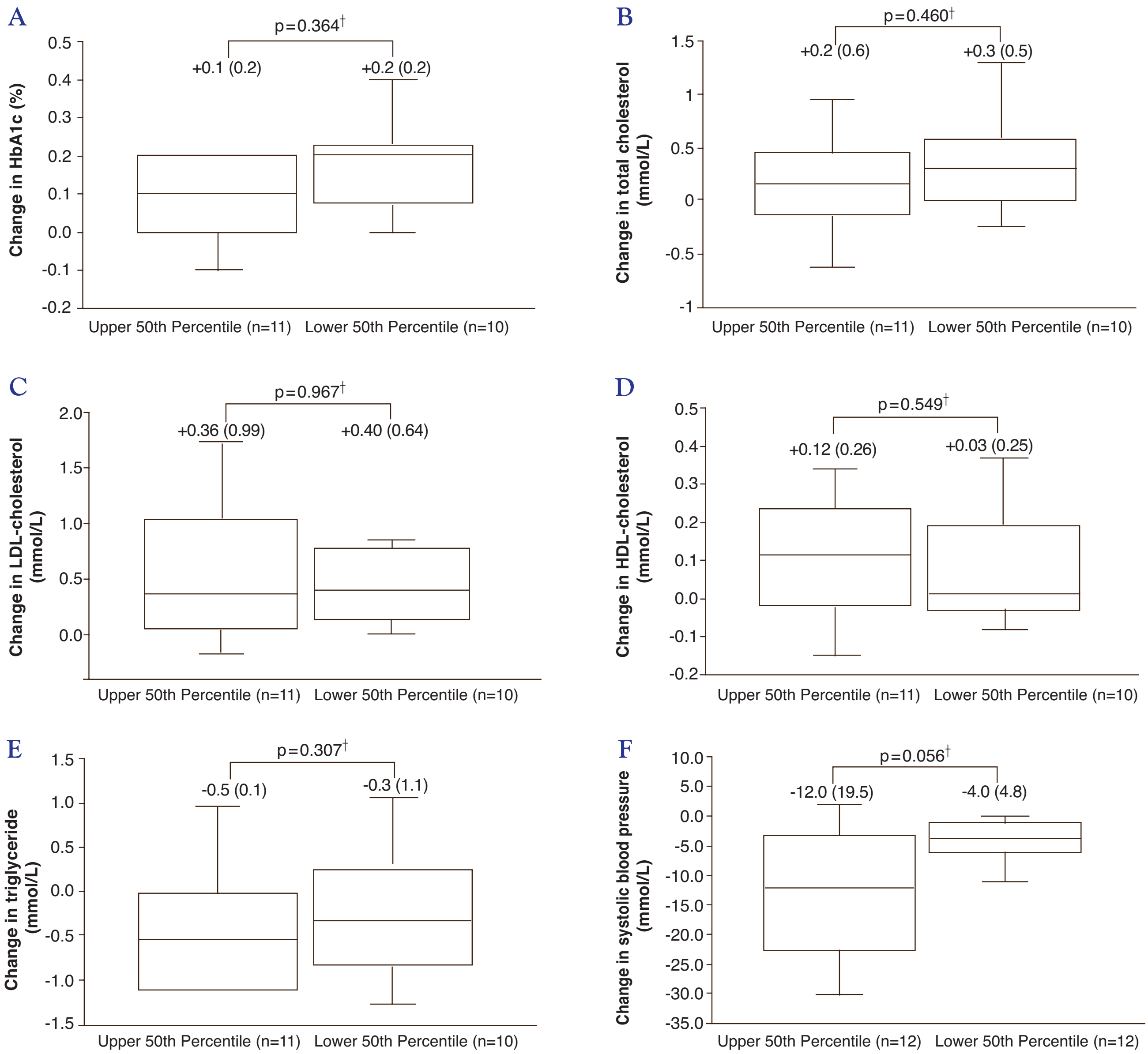
** Statistically significant difference between pre- and post-test results at the level of p<0.05*

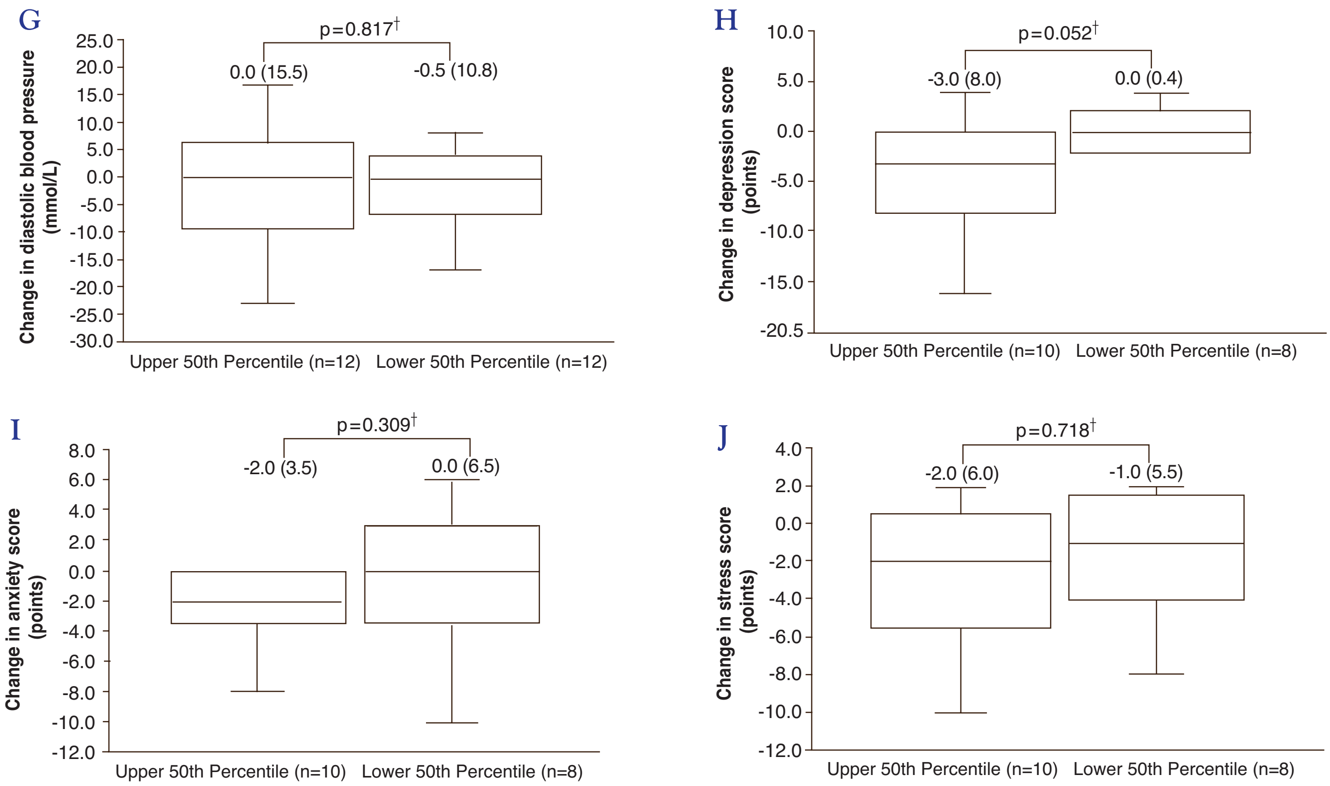
*** Statistically significant difference between pre- and post-test results at the level of p<0.01*

Health outcomes by weight change percentiles

When segregated into upper and lower 50th percentiles of weight change, the median (IQR) change from baseline in body weight was -4.2 (2.4) kg in the upper 50th percentile and -1.3 (2.0) kg in the lower 50th percentile. A Mann-Whitney test showed that the changes in health outcomes were not associated with the degree of weight loss (Figure III).

Figure III: Changes in glycaemic control, lipid profile, blood pressure and mental health status by weight change percentiles.





The box represents the median (IQR), the upper and lower whiskers indicate the minimum and maximum value (outliers are not shown). † = Mann-Whitney test, A = HbA1c, B = total cholesterol, C = LDL-cholesterol, D = HDL-cholesterol, E = Triglyceride, F= Systolic blood pressure, G = Diastolic blood pressure, H = depression score, I = anxiety score, J = stress score

Employee participation

Nearly all the participants (87.5%) attended at least three out of the five group education sessions (Table III). A total of 16 participants self-reported their frequencies of meal-replacement and mobile application use at the end of the intervention. All 16 participants consumed the meal replacements as part of their structured meal plan, with 75% reporting use of meal replacements once a day. Three quarters of the participants used the mobile application during the intervention with varying degrees in the frequency of application use per week.

Table III: Employee participation status by attendance, meal-replacement use, and mobile application use

Participation status	n (%)
Attendance at group sessions (n=24)	
2 sessions	3 (12.5)
3 sessions	8 (33.3)
4 sessions	11 (45.8)
5 sessions	2 (8.3)
Meal-replacement use (n=16)	
1 meal-replacement / day	12 (75.0)
2 meal-replacements / day	4 (25.0)
Mobile application use (n=16)	
No application use / week	4 (25.0)
1 to 2 days of application use / week	5 (31.3)
3 to 4 days of application use / week	6 (37.5)
5 to 7 days of application use / week	1 (6.3)

Relevance and acceptability of the program

The 20 participants that attended the Focus Group Discussion had positive views on the components and impact of the program. The components in the program that helped the participants generate strategies to sustain lifestyle change were the group education sessions, structured meal plan, meal replacements, and timely support given by the dietitians via the mobile health application. The practical skills and simple nutrition messages imparted at the group education sessions were memorable as these gains can be implemented into everyday life.

"I'm more particular in buying. I look at everything. So, I see the calories and everything and then only I buy rather than looking at the packaging itself." [Focus Group 2, Male]

"I think the 'suku-suku separuh' [plate method] is very doable longterm." [Focus group 1, Female]

The participants felt that the illustrated and color-coded meal plan affirmed autonomy when eating a healthy diet.

"I don't call it as diet. I just, I prefer to call it as a structured meal." [Focus Group 2, Male]

"This one I get to eat as I want. Like I have control over my timing." [Focus group 1, Female]

Replacing one to two meals a day with a portion-controlled formulated product reduced the burden of self-care behaviors.

".. because we don't need to think about many things, [like] what to consume." [Focus Group 2, Female]

"But sometimes dinner also I take the replacement meal. It's good. Save my time." [Focus Group 2, Female]

Timely feedback after uploading of food photos and nudges from the diet coach helped the participants build a self-monitoring habit.

"Food journal because all the dietitian, they will reply, comment." [Focus Group 3, Female]

"I have set target not to eat 'nasi lemak' for two, two months when we started this program and I achieved that. So, I'm going to continue it." [Focus Group 2, Female]

The participants' social environment appeared to both reinforce and detract from their newly developed lifestyle change. Changes to routine and lifestyle preferences of important others seemingly disrupt participant adherence. Weight loss of the participants positively affected their family and colleagues.

"End of last year. Because uh, we have all those unavoidable 'makan makan' [social dining]." [Focus Group 2, Male]

"Dinner we're with our family so, tsk, it's difficult to be on a diet when we're with our family." [Focus Group 2, Female]

"At first my parents, uhm, didn't believe, like I will follow the [program]. Then now because they saw me like I lose some weight then they start to ask. I mean like they can see the outcomes from this program." [Focus Group 3, Female]

"So from there I teach them what food that can take, the good food." [Focus Group 3, Female]

Discussion

This present study showed that the IMUHEALxNaluri program elicited significant weight and BMI reductions. These results corroborate related study findings that workplace wellness programs are useful obesity interventions.[17] The magnitude of weight reduction seen in this present study is comparable to that shown in clinical trials involving reduced energy diets, wherein a mean weight loss of 5 to 8.5 kg was observed during the first 6 months of the intervention.[18]

Of remark, this present study showed that the post-intervention reduction in systolic blood pressure was clinically meaningful and comparable to that shown in trials that limit sodium intake,[19] promote the DASH eating plan – a diet rich in vegetables, fruits, whole grains, fat-free or low-fat dairy products, fish, poultry, beans, nuts, and vegetable oils; and low in saturated fat and sugar interventions,[20] and use hypertensive medications.[21] While this present study did not titrate use of hypertensive medications, the structured meal plan encouraged the participants to choose food that are low in saturated fat, sugar and salt, and high in fibre. A systematic review and network meta-analysis demonstrated that reducing systolic blood pressure to below recommended targets may reduce the risk of cardiovascular disease and all-cause mortality.[22]

An unexpected finding of this present study was the juxtaposed post-intervention improvements in triglyceride and HDL-cholesterol levels, but regression in LDL-cholesterol level. Weight loss interventions primarily demonstrate an improvement in lipid profile where a reduction in body weight is accompanied by a reduction in blood triglyceride and LDL-cholesterol, and an increase in HDL-cholesterol levels.[23] Exceptions to this are participants who experienced major weight loss or were following reduced sodium diets. Major weight loss can result in a transient increase in blood cholesterol levels, resulting from mobilisation of adipose cholesterol stores.[24] Nonetheless, the weight loss seen in this present study is average and not likely to have contributed to the increase in blood cholesterol levels. This present study however recommended use of low-sodium over high-sodium food choices. A systematic review showed that a proportion of participants who reduced sodium intake to healthy eating recommendations had an increase in total-cholesterol and LDL-cholesterol.[19] The inverse relationship between blood cholesterol and sodium intake can be explained by the upregulation of epinephrine, renin and angiotensin to revert low plasma volume as reduced sodium intake can reduce body water content.[25]

The focus group results of this present study showed good employee acceptability driven by the use of practical nutrition knowledge in the group education sessions and structured meal plans. Practical nutrition knowledge is considered more relevant and closely related to dieatary intake than factual nutrition knowledge.[26] The use of meal-replacements in this current study also reduced the burden of self-care related to meal planning. Use of meal replacements improve convenience and dietary structure by reducing the number of decisions required for food choices.[27] This current study also used a mobile health application to ensure timely feedback on eating behavior is given to the participants after they upload photos of their meals. This cue to action facilitated self-monitoring of dietary intake. Self-monitoring of dietary intake is an important factor to support dietary adherence and weight loss in behavior-based weight-loss intervention programs.[28]

In this current study, the participants who were lost to follow-up cited conflict with work as a reason. The focus group discussion also shed light on how social pressures detract from the lifestyle changes the participants were trying to make. Indeed, lack of time when finding a balance among life's obligations, and social pressures including work routines, holidays and influence of peers, act as barriers to lifestyle change.[29]

Some limitations of this current study should be noted. There is a known trend of weight regain after weight loss, but the short-term nature of this present study precludes interpretation of its sustainability.[30] Caution should also be applied when generalizing this study findings to a broader workplace setting as this pilot study involved voluntary participation of a small segment of employees who work in a healthcare education setting, not all of whom had obesity related comorbidities. In addition, medication and dietary intake was not measured and as such, the associations of these parameters and health outcomes cannot be elucidated. Future research should assess the scalability of hybrid workplace wellness programs to include long-term follow-up for deeper insights into weight loss and cardiovascular risk reduction over time.

Conclusion

This study demonstrated that the IMUHEALxNaluri program resulted in good employee acceptability and significant clinical improvements including weight loss, improvements in blood triglyceride and blood pressure.

Acknowledgements: Naluri Hidup Sdn Bhd – use of the mobile health application; Jamilah Jamil, Shu Hwa Ong, Charmaine Lavinia, Pheh Huang Soh, and Siti Nurhana Abd Wahid – dietitians who facilitated the program

Funding: This study was internally funded by the International Medical University (IMU), Kuala Lumpur, Malaysia. The authors received no additional financial support for the research, authorship, and/or publication of this article.

Conflict of interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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