

Lifestyle intervention using a mobile application versus booklet for adults with metabolic syndrome: a multicentre randomised controlled trial (abridged secondary publication)

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KEY MESSAGES

1. Compared with usual care, lifestyle intervention using educational support via the MetS app or booklet led to significantly greater reductions in body weight, waist circumference, body mass index, and systolic blood pressure, as well as increased total exercise time and amount, within 24 weeks.
2. Educational support via the MetS app was superior to that via a booklet for lifestyle intervention.
3. The Health Belief Model serves as an effective framework for designing intervention

programmes for exercise initiation and adherence in patients with metabolic syndrome.

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Introduction

Metabolic syndrome—characterised by abdominal obesity, insulin resistance, hypertension, and hyperlipidaemia—is associated with elevated risks of diabetes, prediabetes, and cardiovascular disease.¹ E-health technology through mobile phones provides an effective means for delivering educational interventions to support patients with diabetes or metabolic syndrome.² The effects of e-health interventions compared with usual care or booklet-based approaches are usually reported separately.³

Considering the advantages of e-health programmes for patients with cardiometabolic diseases and the widespread smartphone usage among adults in Hong Kong,^{1,2} we incorporated a custom-designed mobile application into an existing lifestyle intervention programme for patients with metabolic syndrome. This study aimed to compare health-related outcomes over 24 weeks among Hong Kong community adults with metabolic syndrome who received a health education programme using the MetS app, a booklet, or usual care.

Methods

This assessor-blinded, randomised controlled trial was conducted between August 2019 and December 2021. Chinese patients with metabolic syndrome who owned a smartphone and could read Chinese were recruited at two community centres in Hong Kong. Patients with physical, mental, visual, or cognitive impairments, or patients receiving

prescribed medication for weight reduction were excluded.

Participants were randomly assigned to the app group, booklet group, or control group. All participants attended a 30-minute health talk related to metabolic syndrome care. Participants in the app group had the MetS app installed on their smartphones to view educational content. Additionally, a membership area within the app provided individual support for self-health monitoring, goal setting for exercise plans, and exercise tracking. The membership area and interactive platform enabled participants to self-monitor exercise, body weight, and waist circumference, thereby enhancing self-efficacy for exercise initiation, self-monitoring, and adherence. The design of the app was guided by the Health Belief Model.⁴ These participants received one automated health message each day. Participants in the booklet group received a lifestyle intervention booklet, which included information about metabolic syndrome and advice on diet, exercise, medication, lifestyle, and stress management.³ Participants in the control group were advised to maintain their usual activities; they received a placebo leaflet containing health information about obesity and a healthy lifestyle.

Outcome measures included body weight, total exercise time and amount, improvement in any two cardiometabolic risk factors (waist circumference, body mass index, systolic blood pressure, high-density lipoprotein cholesterol, triglycerides, and blood glucose level), cardiovascular endurance,

exercise self-efficacy, and stress level. Outcomes were assessed at baseline, 4 weeks, 12 weeks, and 24 weeks.

All tests were two-sided, and a P value of <0.05 was considered statistically significant. The intention-to-treat principle was applied. Generalised estimating equation models, adjusted for any confounders, were used to compare changes in outcomes over time between groups.

Results

Of 368 patients screened, 264 (71.7%) completed the baseline assessment and were randomly assigned

to the app group (n=88), booklet group (n=88), or control group (n=88). The dropout rates were 8%, 6.8%, and 4.8%, respectively. The three groups were comparable in terms of baseline characteristics, except for sex, education level, and marital status (Table 1). Generalised estimating equation analyses were adjusted for the effects of these three variables on study outcomes.

Compared with the control group, the app group showed greater reductions in body weight, with the reductions increasing over time, whereas the booklet group displayed no significant difference in body weight reduction across the three time points (Table 2). Similarly, the app group achieved a

TABLE 1. Baseline characteristics of participants (n=264)

Variable	App group (n=88)*	Booklet group (n=88)*	Control group (n=88)*	P value
Sex				0.002
Male	35 (39.8)	18 (20.5)	16 (18.2)	
Female	53 (60.2)	70 (79.5)	72 (81.8)	
Age, y	61.59±10.30	62.10±8.29	63.56±12.73	0.444
Education level				<0.001
Primary school/no formal education	13 (14.8)	11 (12.5)	31 (35.2)	
Secondary school	42 (47.7)	61 (69.3)	38 (43.2)	
Tertiary education	33 (37.5)	16 (18.2)	19 (21.6)	
Marital status				0.043
Married	64 (72.7)	48 (54.5)	55 (62.5)	
Unmarried/widowed/divorced/separated	24 (27.3)	40 (45.5)	33 (37.5)	
Employment				0.479
Full-time job	22 (25.0)	21 (23.9)	26 (29.5)	
Part-time job	9 (10.2)	9 (10.2)	9 (10.2)	
Housewife	12 (13.6)	17 (19.3)	21 (23.9)	
Retired/others	45 (51.1)	41 (46.6)	32 (36.4)	
Financial status				0.094
Good	23 (26.1)	13 (14.8)	17 (19.3)	
Average	56 (63.6)	66 (75.0)	54 (61.4)	
Poor	9 (10.2)	9 (10.2)	17 (19.3)	
Residential status				0.112
Live alone	10 (11.4)	21 (23.9)	20 (22.7)	
Live with family	78 (88.6)	67 (76.1)	68 (77.3)	
Exercise				0.784
Regularly	51 (58.0)	44 (50.0)	46 (52.3)	
Sometimes	33 (37.5)	38 (43.2)	35 (39.8)	
No	4 (4.5)	6 (6.8)	7 (8.0)	
Smoking				0.238
Current smoker	1 (1.1)	0	4 (4.5)	
Former smoker	7 (8.0)	8 (9.1)	6 (6.8)	
Never smoker	80 (90.9)	80 (90.9)	78 (88.6)	

* Data are presented as mean ± standard deviation or No. (%) of participants

TABLE 2. Comparisons of outcomes among the app, booklet, and control groups across three time points

Outcome	App and booklet vs control*	P value	App vs booklet*	P value
Body weight, kg				
App group				
Week 4	-0.351 (-0.655 to -0.047)	0.024	-0.400 (-1.000 to 0.201)	0.192
Week 12	-1.044 (-1.613 to -0.476)	<0.001	-0.674 (-1.374 to 0.025)	0.059
Week 24	-1.710 (-2.423 to -0.998)	<0.001	-1.244 (-2.041 to -0.446)	0.002
Booklet group				
Week 4	0.055 (-0.522 to 0.631)	0.853	-	-
Week 12	-0.352 (-1.005 to 0.301)	0.291	-	-
Week 24	-0.435 (-1.126 to 0.257)	0.218	-	-
Total exercise time and amount				
App group				
Week 4	7.511 (1.528 to 13.493)	0.014	8.337 (0.545 to 16.128)	0.036
Week 12	11.315 (5.353 to 17.278)	<0.001	4.467 (-2.509 to 11.443)	0.209
Week 24	11.950 (5.486 to 18.414)	<0.001	11.621 (5.146 to 18.095)	<0.001
Booklet group				
Week 4	-0.768 (-8.208 to 6.672)	0.840	-	-
Week 12	6.926 (-0.632 to 13.219)	0.031	-	-
Week 24	0.387 (-5.006 to 5.780)	0.888	-	-
Waist circumference, cm				
App group				
Week 12	-3.458 (-4.898 to -2.017)	<0.001	-1.186 (-2.484 to 0.112)	0.073
Week 24	-4.696 (-5.927 to -3.466)	<0.001	-2.731 (-4.091 to -1.371)	<0.001
Booklet group				
Week 12	-2.287 (-3.827 to -0.747)	0.004	-	-
Week 24	-1.954 (-3.256 to -0.651)	0.003	-	-
Body mass index				
App group				
Week 4	-0.263 (-0.525 to 2.921)	0.050	-0.153 (-0.376 to 0.071)	0.181
Week 12	-0.494 (-0.805 to -0.183)	0.002	-0.250 (-0.512 to 0.013)	0.062
Week 24	-0.799 (-1.152 to -0.445)	<0.001	-0.477 (-0.777 to -0.176)	0.002
Booklet group				
Week 4	-0.109 (-0.427 to 0.208)	0.499	-	-
Week 12	-0.242 (-0.573 to 0.089)	0.151	-	-
Week 24	-0.318 (-0.661 to 0.025)	0.069	-	-
Systolic blood pressure				
App group				
Week 12	-4.122 (-8.112 to -0.133)	0.043	-1.520 (-5.445 to 2.406)	0.448
Week 24	-2.442 (-7.001 to 2.118)	0.294	-4.919 (-9.260 to -0.578)	0.026
Booklet group				
Week 12	-2.615 (-6.841 to 1.611)	0.225	-	-
Week 24	2.468 (-2.073 to 7.009)	0.287	-	-
Diastolic blood pressure				
App group				
Week 12	-1.766 (-4.190 to 0.659)	0.153	0.005 (-2.255 to 2.265)	0.996
Week 24	-1.520 (-3.904 to 0.865)	0.212	-1.686 (-4.201 to 0.829)	0.189
Booklet group				
Week 12	-1.719 (-4.037 to 0.599)	0.146	-	-
Week 24	0.213 (-2.250 to 2.677)	0.865	-	-

* Data are presented as beta coefficient (95% confidence interval)

TABLE 2. (cont'd)

Outcome	App and booklet vs control*	P value	App vs booklet*	P value
High-density lipoprotein cholesterol				
App group				
Week 12	-0.007 (-0.074 to 0.059)	0.831	0.049 (-0.017 to 0.114)	0.146
Week 24	-0.055 (-0.129 to 0.019)	0.147	-	-
Triglycerides				
App group				
Week 12	0.009 (-0.327 to 0.345)	0.957	-0.179 (-0.508 to 0.228)	0.397
Week 24	0.191 (-0.108 to 0.490)	0.210	-	-
Fasting blood glucose				
App group				
Week 12	0.100 (-0.154 to 0.354)	0.441	-0.041 (-0.248 to 0.165)	0.694
Week 24	0.276 (-0.001 to 0.553)	0.051	0.030 (-0.176 to 0.235)	0.777
Booklet group				
Week 12	0.141 (-0.119 to 0.401)	0.289	-	-
Week 24	0.245 (-0.043 to 0.533)	0.095	-	-
3-mins step test				
App group				
Week 12	0.107 (-0.342 to 0.557)	0.640	0.098 (-0.423 to 0.620)	0.711
Week 24	0.048 (-0.424 to 0.519)	0.843	-0.057 (-0.579 to 0.466)	0.832
Booklet group				
Week 12	0.008 (-0.491 to 0.507)	0.976	-	-
Week 24	0.100 (-0.389 to 0.590)	0.688	-	-
Self-efficacy for exercise				
App group				
Week 4	0.259 (-0.278 to 0.795)	0.345	0.062 (-0.522 to 0.646)	0.836
Week 12	0.557 (-0.096 to 1.210)	0.095	0.042 (-0.574 to 0.657)	0.894
Week 24	0.408 (-0.287 to 1.102)	0.250	0.266 (-0.361 to 0.892)	0.406
Booklet group				
Week 4	0.203 (-0.467 to 0.874)	0.552	-	-
Week 12	0.536 (-0.209 to 1.280)	0.158	-	-
Week 24	0.241 (-0.498 to 0.981)	0.522	-	-
Perceived stress scale				
App group				
Week 4	-0.579 (-1.810 to 0.652)	0.357	-0.291 (-1.590 to 1.008)	0.661
Week 12	-0.103 (-1.626 to 1.419)	0.894	0.484 (-0.940 to 1.909)	0.505
Week 24	-0.319 (-2.382 to 1.744)	0.762	-0.215 (-1.927 to 1.498)	0.806
Booklet group				
Week 4	-0.285 (-1.525 to 0.954)	0.652	-	-
Week 12	-0.594 (-2.036 to 0.848)	0.420	-	-
Week 24	-0.111 (-2.055 to 1.834)	0.911	-	-

greater increase in exercise time at each time point. Regarding cardiometabolic risk factors, both the app and booklet groups exhibited significant reductions in waist circumference at weeks 12 and 24; effects were greater in the app group than in the booklet group. Compared with the control group, the app group also showed significant reductions in body mass index at weeks 12 and 24 and in systolic blood pressure at week 12. Compared with the control group, both the app and booklet groups had greater improvements in the cardiovascular endurance (as measured by the 3-min step test) and self-efficacy for exercise, and larger reductions in perceived stress at all three time points.

Compared with the booklet group, the app group showed greater reduction in body weight at week 24, increased total exercise time and amount at weeks 4 and 24, and reductions in waist circumference, body mass index, and systolic blood pressure at week 24.

Discussion

The lifestyle intervention programme via the MetS app was superior to that via a booklet in reducing body weight, body mass index, waist circumference, and systolic blood pressure, as well as increasing total exercise time and amount, within 24 weeks. These results suggest that the app effectively promoted regular aerobic exercise, leading to reductions in weight and central obesity. Our findings are consistent with the literature, which shows that a structured e-health programme with features to support self-monitoring, feedback, and goal setting can facilitate behavioural changes (eg, increased exercise frequency and duration).⁵ The MetS app may have motivated participants to engage in dietary control, exercise initiation, and adherence, leading to greater total exercise time and amount and body weight reduction.⁵

Fluctuations in exercise self-efficacy were observed in the booklet and control groups, but exercise self-efficacy was significantly improved in the app group. These fluctuations might reflect the limited effect duration (4 weeks) of the nurse-led health talk at baseline. No significant improvements were observed for stress management, although a trend toward stress reduction was observed in the app and booklet groups.

Conclusion

The lifestyle intervention programme via the MetS app was superior to that via a booklet in reducing

body weight, body mass index, waist circumference, and systolic blood pressure, as well as increasing exercise time and amount, within 24 weeks.

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1. Wong EML, Tam HL, Leung AYM, Cheung ASP, Cheung KC, Leung DYP. Impacts of educational interventions with support of mobile app versus booklet for patients with hypertension and metabolic syndrome: a secondary data analysis. *Int J Environ Res Public Health* 2022;19:12591.
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