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Effect of maintaining supervised gym- and home-based exercises on the seasonal variations of metabolic outcomes in overweight and obese Japanese adults

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ABSTRACT

Objectives This study aimed to examine whether maintaining supervised gym- and home-based exercises for an extended time of period could decrease seasonal variations of metabolic outcomes in overweight and obese Japanese adults.

Methods This retrospective study recruited 54 overweight and obese outpatients who started exercising in 2006–2010 and analysed their metabolic outcomes for 5 years from March 2011 to February 2016. In this group, 26 participants performed moderate-intensity aerobic exercise (MIAE) for 30–40 min/day for at least 2 days/week, supervised by physical therapists at a hospital gym (GYM) during the observation period. Conversely, 28 participants were asked to perform MIAE by themselves at or around their homes (HOME) for the same duration.

Results The body mass index (BMI), waist circumference and homoeostasis model assessment of insulin resistance (HOMA-IR) values in winter were higher than those in other seasons in the HOME group but not in the GYM group. The annual ranges of BMI, waist circumference, fasting plasma glucose and HOMA-IR in the GYM group were smaller than those in the HOME group.

Conclusion Maintaining supervised gym-based exercise, as opposed to home-based exercise, may decrease seasonal variations of some metabolic outcomes in overweight and obese Japanese adults.

What are the new findings

- Supervised gym-based moderate-intensity aerobic exercise (MIAE) is a useful method to maintain exercise habits regardless of climate conditions.
- Overweight and obese Japanese adults who have performed regular MIAE at a hospital gym for 5 years could suppress seasonal variations of body weight, waist circumference and insulin resistance.
- Maintaining supervised gym-based MIAE may be a more important strategy for the management of metabolic outcomes, compared with home-based exercise.

INTRODUCTION

Seasonal variations of climate conditions may affect the amount of physical activity (PA) people undertake, due to the reduction of opportunity for participating in sports, exercise and leisure-time activities.[1 2] People have been found to be less active and more sedentary during winter than during spring and summer.[1 2] Generally, seasonal variations of metabolic outcomes, which may be as a result of changes in PA during seasons, are often observed.[3–6] Total PA varied seasonally in people with type 2 diabetes, which led to poor glycaemic control in winter.[7] Additionally, previous studies reported that lipid profiles and body weight had seasonal variations in overweight and obese people, as their PA in winter was reduced compared with that in summer.[8 9]

However, little is known about the association between maintaining regular PA and seasonal variations of metabolic outcomes in overweight and obese Japanese adults. Most Japanese live in a humid subtropical climate, and they receive various treatments in accordance with their climatic condition (eg, high humidity), residential environment (eg, few parks around houses), dietary habits (eg, high sodium meals) and physique (eg, relatively low weight), which differ from those of other countries; hence, it is uncertain whether the results in other countries[3 8] can be applied to Japanese people. To address these issues, we examined whether promoting regular PA, focusing on supervised gym- and home-based exercises, prevented seasonal variations of metabolic outcomes in overweight and obese Japanese adults.

METHODS

Participants

Overall, 112 overweight and obese adults aged 50–75 years regularly visited the Toyooka Hospital Hidaka Medical Centre (Toyooka, Japan) as outpatients from 2006 to 2010. All

participants were under medical nutritional therapy (energy intake: 25–30 kcal/kg/day) supervised once every 1–2 months by dieticians, and 91 of them were taking oral agents (eg, hypolipemic agents). All participants provided written informed consent.

Study design and exercise protocol

Although not measured by objective methods, at the start of the outpatient visits, all participants held positive attitudes towards exercise, freely chose the place where they wanted to exercise and performed regular exercise at a hospital gym, or at or around their homes. We retrospectively observed their metabolic outcome data for 5 years (from March 2011 to February 2016) to overcome the effects of any climatic conditions that may have occurred in a single year.

Participants who were hospitalised presented with diseases that affect PA, or were under insulin therapy during the period were excluded. Finally, we analysed 54 participants (figure 1): 27, 29 and 14 participants had dyslipidaemia, hypertension and diabetes, respectively.

Prior to performing exercise, participants underwent a cardiopulmonary exercise test using a bicycle ergometer to evaluate their peak oxygen uptake ($\dot{V}O_2$peak). After the test, they received instructions about the exercise and performed moderate-intensity aerobic exercise (MIAE) (40%–60% $\dot{V}O_2$peak) using a bicycle ergometer or treadmill.

Twenty-six participants performed regular MIAE using a bicycle ergometer or treadmill for 30–40 min/day for at least 2 days/week at our hospital gym (GYM), supervised (eg, monitoring heart rate and rating of perceived exertion and instructing exercise intensity) by the same two physical therapists during the period. The timing of exercise was from 8:30 to 17:00. Conversely, 28 participants freely chose the timing of exercise and performed self-managed MIAE (eg, walking, jogging) for the same duration at or around their homes (HOME). The participants received advice about the exercise when they visited the hospital once every 1–2 months. They recorded their progress using self-recording papers that were provided. Performing

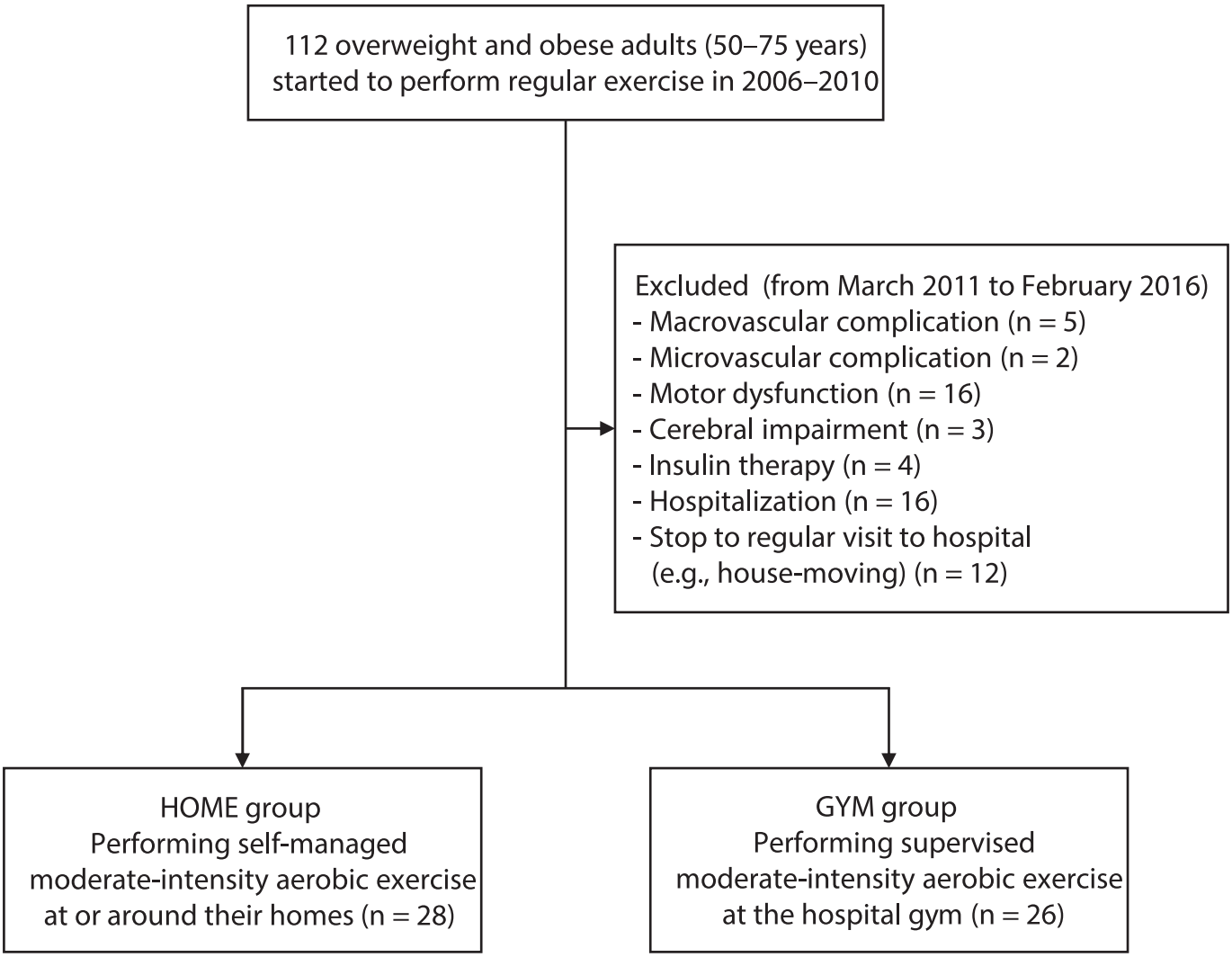

Figure 1 Flow chart of the study population selection, including participant recruitment. GYM, people who performed supervised exercise at the hospital gym; HOME, people who performed self-managed exercise at or around their homes.

exercises alone or in a group setting was not considered to be relevant for either group's outcome.

Measurements

Metabolic outcomes in different seasons (spring, April/May; summer, July/August; autumn, October/November; winter, January/February) were measured in the morning after an overnight fast.

Statistical analysis

All values are reported as mean±SD. Variables at the start of the observation (baseline) were compared between the HOME and GYM groups using the independent t-test and Fisher's exact test. We compared the metabolic outcomes among seasons and exercise conditions using a two-way repeated measures analysis of variance (two-way ANOVA), followed by Tukey-Kramer post hoc test. In addition, the annual ranges of the variables were compared between the two groups using independent t-test. The results were analysed using IBM SPSS statistics (version 20.0, IBM, Tokyo, Japan). A value of p<0.05 was considered significant.

RESULTS

Physical characteristics

The baseline characteristics of the analysed participants are shown in table 1. During the period, many participants in the HOME group gradually experienced negative attitudes towards exercise, and they were unable to maintain the recommended exercise habits (the proportion of participants fully adherent (for 30–40 min/day and ≥2 days/week): HOME, 15%; GYM, 54%).

Table 1 Characteristics of the study participants at baseline

Variables	Total (n=54)	HOME (n=26)	GYM (n=28)
Gender (male/female)	21/33	11/15	10/18
Age (years)	65.8±8.7	66.3±9.1	65.2±7.3
Cigarette smoking (≥1 time/day), n (%)	6 (13.3)	3 (14.3)	3 (12.5)
Alcohol drinking (≥1 day/week, alcohol ≥20 g/day), n, %	13 (28.9)	6 (28.6)	7 (29.2)
BMI (kg/m^2)	29.5±2.9	29.7±3.4	29.3±2.4*
Waist circumference (cm)	94.1±7.4	95.5±8.3	92.7±6.6*
FPG (mmol/L)	5.6±0.6	5.7±0.7	5.5±0.5
HOMA-IR	1.8±0.5	2.0±0.7	1.6±0.8**
Systolic BP (mmHg)	135.0 ±11.7	140.4 ±15.1	129.1±12.9*
Diastolic BP (mmHg)	74.0±9.9	77.4±6.9	70.6±10.8*
Triglycerides (mmol/L)	1.4±0.3	1.5±0.2	1.4±0.2
LDL cholesterol (mmol/L)	3.4±0.4	3.5±0.3	3.3±0.4
HDL cholesterol (mmol/L)	1.6±0.4	1.5±0.3	1.7±0.3

*p<0.05, **p<0.01 versus corresponding HOME group.
BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; GYM, people who performed supervised exercise at the hospital gym; HOME, people who performed self-managed exercise at or around their homes; HOMA-IR, homoeostasis model assessment of insulin resistance; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Values are presented as mean±SD.

Changes in metabolic outcomes

Two-way ANOVA showed a significant interaction between seasons and exercise conditions on body mass index (BMI), waist circumference and homoeostasis model assessment of insulin resistance (HOMA-IR) (all p<0.01), the values of which were higher in winter in the HOME group than in other seasons in the HOME group and in winter in the GYM group (all p<0.01) (table 2). Conversely, there were no significant differences in the values among seasons in the GYM group. The annual ranges of the BMI, waist circumference, fasting plasma glucose (FPG) and HOMA-IR values in the GYM group were smaller than those in the HOME group (p<0.01,

Table 2 Comparisons of metabolic outcomes among seasons

Variables	Group	Spring	Summer	Autumn	Winter
BMI (kg/m^2)	HOME	29.2±2.4‡	28.9±3.3†‡	29.4±2.6**‡	29.8±2.9**
	GYM	28.9±2.1	28.7±2.2	28.8±2.8	28.9±2.0
Waist circumference (cm)	HOME	93.8±9.5*‡	93.1±8.4‡	94.3±7.5**‡	95.7±4.2**
	GYM	92.6±6.9	92.4±4.6	92.6±5.3	92.8±6.1
FPG (mmol/L)	HOME	5.6±0.6	5.6±0.7	5.7±0.9	5.8±0.8
	GYM	5.6±0.4	5.5±0.6	5.6±0.5	5.6±0.6
HOMA-IR	HOME	1.8±0.5‡	1.8±0.7‡	1.8±0.8‡	2.0±0.6**
	GYM	1.8±0.7	1.8±0.5	1.8±0.4	1.8±0.5
Systolic BP (mmHg)	HOME	129.7±11.6	125.7±13.6	130.8±12.8	134.7±10.2
	GYM	126.7±10.8	124.6±11.9	129.6±16.0	130.5±9.6
Diastolic BP (mmHg)	HOME	72.0±7.5	71.7±9.3	72.2±6.8	73.6±9.3

Continued

Table 2 Continued

Variables	Group	Spring	Summer	Autumn	Winter
	GYM	69.5±8.4	69.2±9.8	69.5±11.1	69.3±8.2
Triglyceride (mmol/L)	HOME	1.5±0.3	1.5±0.4	1.5±0.2	1.5±0.2
	GYM	1.5±0.2	1.5±0.2	1.5±0.3	1.5±0.4
LDL cholesterol (mmol/L)	HOME	3.5±0.3	3.5±0.2	3.5±0.2	3.6±0.3
	GYM	3.4±0.3	3.3±0.2	3.4±0.4	3.4±0.2
HDL cholesterol (mmol/L)	HOME	1.5±0.2	1.5±0.2	1.5±0.2	1.4±0.3
	GYM	1.6±0.2	1.5±0.2	1.5±0.3	1.5±0.2

*p<0.05, **p<0.01 versus corresponding GYM group.
†p<0.01 and ‡p<0.01 versus corresponding autumn and winter in the same group, respectively.
BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; GYM, people who performed supervised exercise at the hospital gym; HOME, people who performed self-managed exercise at or around their homes; HOMA-IR, homoeostasis model assessment of insulin resistance; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Values are presented as mean±SD.

p<0.01, p<0.05, p<0.01, respectively) (figure 2A–D). There were no significant interactions between seasons and exercise conditions, although the main effects of seasons and exercise conditions on systolic and diastolic blood pressure (BP) were noted (both p<0.01); there were no significant differences in the annual ranges of other outcomes (table 2 and figure 2E–I).

DISCUSSION

Findings and comparisons between gym- and home-based MIAE

Our research found that MIAE in the GYM group at 54% adherence suppressed seasonal variations of body weight, waist circumference and insulin resistance, compared with the HOME group at 15% adherence. Gym-based exercise may also be more effective in maintaining exercise habits independent of climate conditions when compared with home-based exercise. Attending a gym-based exercise programme allows supervision of participants. A previous review showed that exercise interventions with feedback and monitoring demonstrated positive results for adherence.[10] Additionally, evidence suggests that supervision may have a lower attrition rate than self-selected exercise and may induce better long-term metabolic outcomes.[11 12] Therefore, gym exercise may be better at suppressing seasonal variations of metabolic outcomes by maintaining exercise habits throughout the year compared with home exercise.

In the present study, regular MIAE in a gym effectively managed metabolic outcomes, although the proportion of participants fully adherent (for 30–40 min/day and ≥2 days/week) was 54%. However, there is conflicting evidence regarding the ideal dose in terms of PA levels to improve metabolic outcomes. A recent review showed that moderate-to-vigorous PA of short duration, even <10 min, was associated with improved BMI, BP, FPG, blood lipids and metabolic syndrome.[13] Future research is needed to confirm an appropriate dose of MIAE for suppressing seasonal variations of metabolic outcomes.

Physiological responses to climate conditions

Winter may be the best season for weight loss and glucose and lipid metabolism due to an increase in available metabolites, including ready mobilisation of fat.[14] However, exposure to low temperature induces various physiological responses by the sympathetic nervous system activity and hormones.[15 16] Low temperature increases blood glucose concentration[17–20] and arteriolar vasoconstriction.[21 22] Additionally, the decrease in vitamin D synthesis, typically obtained through sun exposure and inhibits the renin-angiotensin system, in winter can increase BP levels.[22] In our study area, the outdoor temperature and daylight time in winter were 3.7°C and 63.5 hours/month, which were lower than in other regions; for example, 6.5°C and 177.0 hours/month,[23] respectively, in Tokyo. Hence, participants who maintain exercise habits even in winter may prevent deterioration of other metabolic outcomes, although that in BP.

Study strengths, limitations and conclusion

The biggest strength of the present study is that no previous study has investigated the association of seasonal variation and regular PA in overweight and obese Japanese adults, and we believe that our findings will contribute to the management of this cohort's metabolic outcomes. However, this study has some weaknesses. First, this study is a retrospective design with small samples, and the study participants were uncomplicated adults. Second, PA and dietary habits in both groups were not evaluated objectively. Thus, further studies, such as an approach to maintain a home-based exercise, are needed to confirm the findings of this study.

In conclusion, long-term supervised gym-based MIAE decreased the seasonal variations of body weight, waist circumference and insulin resistance in overweight and obese Japanese adults, compared with home-based exercise. Although further studies are needed, an exercise method that is not influenced by outdoor environments

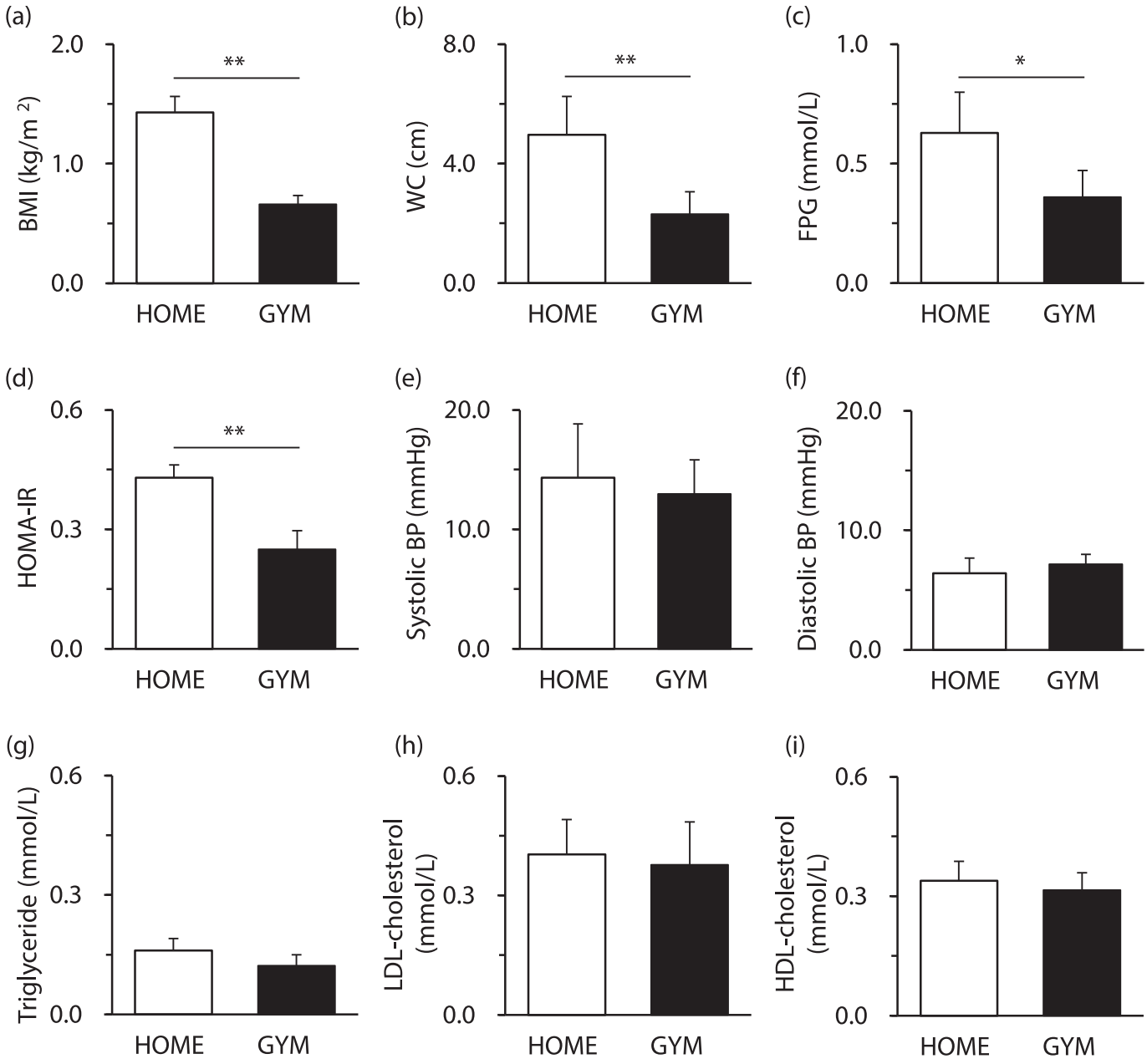

Figure 2 Comparisons of annual ranges between the HOME and GYM groups. (A) BMI (body mass index), (B) WC (waist circumference), (C) FPG (fasting plasma glucose), (D) HOMA-IR (homoeostasis model assessment of insulin resistance), (E) systolic BP (systolic blood pressure), (F) diastolic BP (diastolic blood pressure), (G) triglyceride, (H) LDL-cholesterol (low-density lipoprotein cholesterol) and (I) HDL cholesterol (high-density lipoprotein cholesterol). Values are presented as mean±SD. *p<0.05, **p<0.01. HOME, people who performed self-managed exercise at or around their homes; GYM, people who performed supervised exercise at the hospital gym

and with a regular follow-up by exercise instructors may be an important strategy for the management of metabolic outcomes.

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Competing interests None declared.

Patient consent for publication Not required.

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Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article.

Patient and public involvement Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.

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