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ORIGINAL ARTICLE

Evaluation of the impact of a 20-week exercise referral scheme on Mauritian adults diagnosed with non-communicable diseases

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Abstract

The escalating prevalence of non-communicable diseases (NCD) presents a concern in Mauritius. These diseases, caused by many factors, reflect the social, economic and environmental conditions within which people live and work. Type 2 diabetes mellitus, hypertension and obesity are the most prevalent among Mauritian adults. Within the framework of a comprehensive systems approach aiming at addressing the social determinants of health, there is a need for customised strategies for both management and prevention of non-communicable diseases. One such example is exercise referral. Exercise referral schemes (ERS) represent an emerging tool for helping people become more physically active and healthier. Evidence of their effectiveness is equivocal and lacks contextual insight into their value in a Mauritian context. Hence, this study serves to bridge this gap. We report the outcomes of a 20-week ERS. Two hundred sixty consenting adults recruited from Area Health Centres (AHC) and Mediclinic's around Mauritius were assigned to one of two groups: intervention group (ERS + guidance and support by exercise referral consultant) or control group (exercise 'advice' from a general practitioner). Body mass index (BMI), grip strength, waist circumference, fasting blood sugar (FBS), HbA1c, lipid profile and blood pressure were measured at week 0, 10 and 20. This quasi-experimental longitudinal study successfully demonstrated improvements in parameters associated with risk factors for coronary heart disease, particularly among women in the intervention group. Significant reductions in weight, waist circumference, FBS and BMI at week 10 and 20 were noted. A less pronounced decline in parameters was observed in men, except for waist circumference, which reached near significance ($p = 0.076$). Using female participants as a primary focal point, this study supports the notion of exercise referral as part of a holistic treatment plan to control NCDs. We advocate future ERS initiatives prioritise a patient-centred comprehensive approach in design and implementation to ensure successful outcomes.

Keywords Exercise referral scheme · Non-communicable diseases · Exercise prescription · Mauritian adults · Diabetes · Hypertension · Obesity · Cardiovascular diseases · Dyslipidaemia

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Introduction

Considered to be a global health concern, physical inactivity has been linked to a multitude of chronic and debilitating disorders ranging from cardiovascular disease, obesity, type 2 diabetes mellitus, stroke and musculoskeletal disorders (Saunders et al. 2020; Liang et al. 2022; Cavallo et al. 2022). The high prevalence of non-communicable diseases (NCDs) is attributed to various lifestyle risk factors that reflect the social, economic and environmental determinants of health. Promoting universal wellbeing and mitigating social disparities form the core objectives of public health initiatives. These initiatives necessitate a comprehensive strategy to address lifestyle modifications such as smoking cessation, better eating habits and improved physical activity. However, conveying the imperative of such changes poses a tremendous task, demanding a systems-based approach and a concerted multisectoral effort to instil awareness and understanding amongst the public. As with many other middle-income countries, Mauritius is facing a major health crisis, where the number of NCDs is rising significantly annually. A recent survey conducted by the Ministry of Health and Wellness found that 19.9% of adults aged 25–74 in Mauritius have type 2 diabetes. Mauritius ranks highest in the region of Africa for type 2 diabetes and 12th on the global stand (International Diabetes Federation (IDF) Diabetes Atlas 2021). While 27.2% of the population suffer from hypertension. Despite government-funded healthcare, 49.9% of population still grapple with elevated blood pressure. Furthermore, 68.6% of men and 75.4% of women are classified as overweight or obese (The Mauritius-Non-Communicable-Diseases-Survey 2021). These statistics indicate a significant gap in effective NCD management.

On average, only 28% of adults globally are physically active (World Health Organization 2022). Lack of exercise and physical activity are recognised to be critical contributors to this scenario of ineffective NCD management. The implications of a sedentary lifestyle affect not only individual physical health but transcends beyond health dimensions to geographical, socioeconomic and cultural boundaries, affecting populations worldwide. Only 23% of adults in Mauritius meet the recommended 150 min/week (National Sport and Physical Activity Policy for the Republic of Mauritius 2018). Concerted efforts advocating integration of regular physical activity into daily routines have been endorsed and is supported by evidence. Studies, including those by Hakami et al. (2023), González et al. (2017) and Reiner et al. (2013), demonstrate the pivotal role of regular exercise in mitigating the risk of NCD occurrence and elevating the overall quality of life. The consequences of physical inactivity have now become a shared responsibility that extends across multiple sectors requiring collaborative action, continued support and commitment from governments, communities, healthcare providers and individuals alike, for a lasting impact on global health to be achieved (Gelius et al. 2020; WHO 2018). With support from the Commonwealth, Mauritius has created a National Active Mauritius Framework which allows sports to meaningfully contribute to the UN Sustainable Development Goal for social cohesion, economic development and health (SDG 3.4)—a reduction of premature mortality from NCDs (The Commonwealth 2018). The policy that emerged from this framework has chartered a pathway for capacity building and empowerment of the medical sector to consider prescribing exercise and physical activity as a means of addressing this goal by 2028 (Active Mauritius 2019; National Sport and Physical Activity Policy for the Republic of Mauritius 2018; The Mauritius-Non-Communicable-Diseases-Survey 2021); however, the efficiency of such measure in the local context remained unexplored.

Contrastingly, proactive initiatives within primary health care settings of developed nations such as the United Kingdom, Australia, Canada and the US have implemented exercise referral schemes (ERS) (also known as physical activity on prescription) for several years. These public health initiatives aim to improve the health outcomes of sedentary individuals at risk or dealing with NCDs. With the involvement of a general practitioner, nurse, physiotherapist or specialist, medium to high-risk patients can be referred to a tailored exercise programme for a duration of 10 to 15 weeks (Wade et al. 2020). Rowley et al. (2018) report significantly better outcomes in patients subjected to ERS that last 16 weeks or more. A plethora of compelling evidence exists documenting the positive impacts of physical activity and exercise on pain reduction, blood pressure and resting heart rate, lipid levels, fitness and reduced depression and anxiety levels (Gibbs et al. 2021; Cashin et al. 2022; Tomlinson-Perez et al. 2022; Zampogna et al. 2020). The concept of chronic disease management with structured and guided physical activity is advocated to be a sustainable adjunct to treatment plans, intending to reduce the burden on national healthcare systems. ERS are advantageous to those with limited access to clinical environments and transport while catering to those with little to no access to specialized equipment through the flexibility of activities such as group exercise classes, walking groups and swimming, among others. Such schemes are observed to be more successful when they offer exercise variations and consistent motivational support (Stathi et al. 2004). However, many researchers agree that literature on measurable health outcomes of ERS is scanty. Findings by O'Brien et al. (O'Brien et al. 2021) advocate for recommendations to focus on harmonizing ERS reporting and the integration of post ERS-evaluations. A comprehensive

understanding of behavioural changes exhibited by participants is deemed crucial for designing effective ERS that encourage long-term adoption of physical activity. Hence, the need for an international policy (WHO 2018) to help drive capability and capacity across the system by educating healthcare professionals on the availability of these programmes. This would also enable the use of a standardized implementation method, potentially improving the overall health and wellbeing of the population (National Institute For Health and Care Excellence (NICE) 2014).

Mauritius has achieved a significant milestone by becoming the first African nation to integrate indicators within its national monitoring and evaluation system, facilitating the quantification of diverse domains in which sports has a positive impact (National Action Plan on Physical Activity 2011–2014). This positions the health and medical sectors as primary beneficiaries of this initiative. The Commonwealth report that 57% of Mauritians desire to become more physically active (The Commonwealth 2019). Studies such as the work by Garcia et al. (Garcia et al. 2022) shed light on the numerous barriers that impede individual attendance, adherence and motivation levels. Regardless of the type of incentives offered to participants, one-on-one interactions and the presence of qualified physical activity counselling appear to be motivating solid influencers. This underscores the pivotal role of qualified exercise referral instructors as a key determinant in the success of an ERS (O'Brien et al. 2021).

All government policies must be grounded in evidence-based best practices. Unfortunately, there is a dearth of evidence supporting the effectiveness of exercise referral schemes in addressing NCDs in the African region. As a result, a 20-week study was designed with the main objectives to determine the efficacy of an exercise referral scheme based on the changes of physical and physiological parameters at three distinct time points over a 20-week duration; and evaluate the relevance of ERS amongst participants as a means to overcome sedentary lifestyles. This study is the first of its kind in Mauritius. The outcomes will furnish critical input into the future design, implementation and refinement of evidence-based initiatives tailored to the specific needs and challenges of the Mauritian population as part of a broader policy agenda. The implications of this study can extend beyond Mauritius to countries sharing similar demographic and health profiles, bolstering overall public health on a larger scale.

Methodology

Study site and selection criteria

This study was conducted in four main healthcare institutions across Mauritius: Helvetia Area Health Centre (AHC), L'Escalier Mediclinic, Floreal Mediclinic and Belvedere Mediclinic. These areas were chosen because of a mix of rural and urban population densities. The study aimed to capture the impact or the ERS programmes irrespective of residential barriers and differences. Mauritian adults whom their community physician or general practitioner identified to be sedentary and with risk factors of NCDs were recruited to participate voluntarily in this study. Eligible patients aged between 18 to 75 years, were allowed to participate based on the following inclusion criteria:

Fasting plasma glucose $\geq$ 7.0 mmol/l (126 mg/dl) or 2-h plasma glucose $\geq$ 11.1 mmol/l (200 mg/dl) or glycated haemoglobin A1C $\geq$ 6.5% (American Diabetes Association 2022)
Systolic blood pressure $\geq$ 140 mmHg and/or diastolic blood pressure $\geq$ 90 mmHg (Williams et al. 2018)
Body mass index $\geq$ 30 kg/m^2 (World Health Organization 2022)
Total cholesterol $\geq$ 5 mmol/L ($\geq$ 200 mg/dL), LDL-C > 3 mmol/L (116 mg/dL), Triglycerides $\geq$ 2.2 mmol/L (199 mg/dL) (Mach et al. 2020)

The study used a two-pronged approach with quantitative data collection through anthropometric and blood biomarkers measurements, as well as a brief satisfaction survey (Fig. 1).

Sample size and participant recruitment

The study consisted of an intervention and control group for a total of 260 earmarked respondents. Recruitment was carried out for a period of 4 weeks in all AHCs and Mediclinics simultaneously. Helvetia AHC and L'Escalier Mediclinic were chosen to be intervention sites, as both of these health centres had sports or recreational facilities in the vicinity, which were essential logistics for the exercise programme to be delivered. Thus, patients in Helvetia and L'Escalier health facilities were allocated to the intervention group, while those on Floreal and Belvedere Mediclinic were allocated to the control group. For the intervention group, a total of 120 participants meeting the inclusion criteria were recruited using a stratified sampling strategy, from the participants' records, registered at the Helvetia AHC and L'Escalier Mediclinic, catering for a mix of rural and urban participants to ensure variation in demographics. Moreover, 120 participants were retained for this group as the current healthcare framework does not cater to the ERS, requiring additional human resources to deliver the programme. Studies by Brysbaert (Williams et al. 2018) and Burns et al. (Mach et al. 2020) showed that meaningful data could be retrieved with sample sizes of less than 100 participants provided the group variations were controlled and stable. An equal number of

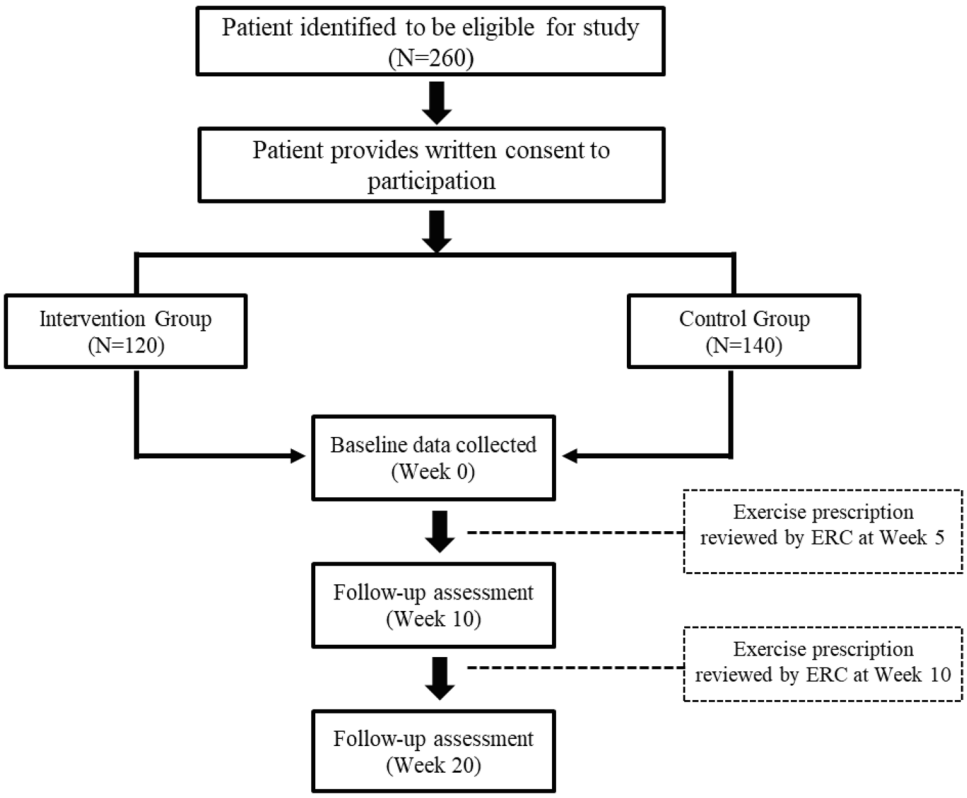

Fig. 1 Study design of the 20-week exercise referral scheme

participants from each centre were earmarked. The same strategy was implemented for the control group, whereby 70 participants from the Floreal and Belvedere Mediclinic groups were recruited.

The intervention group

The 120 participants who were assigned to this group proceeded with an intervention/behaviour change motivation interview (30–45 min) where the goals and targets of the participant for the programme were explored with an exercise referral consultant (ERC). An initial baseline assessment of participants, with respect to their morphometric and blood markers were also tested prior to the onset of the intervention. Participants were prescribed a tailor-made 20-week exercise programme which was reviewed by the ERC, on average every 5 weeks. Three ERCs with formal training in exercise referral were recruited for the purpose of this study. They tailored activities such as general aerobics, strength training, coordination and balance exercises (e.g. swimming classes, exercise for health classes, walking clubs and aqua gym classes), depending on the interest and likelihood of adherence of the participant. A coach from Active Mauritius (a sub-directorate of the Mauritius Sports Council) was also involved in the intervention to support the delivery of community-based exercise throughout the 20 weeks. Participants were also encouraged to enrol in existing pre-programmed activities undertaken by Active Mauritius such as the Walking Club or the Exercise for Health Classes; activity levels were also computed while designing the final activity profiles. An example of a strength training routine that was prescribed during the first week of referral would be four sets of five repetitions of exercise to mimic a squat pattern (e.g. chair squat), a hinge pattern exercise (e.g. body weight deadlift), a push pattern (e.g. push wall), a suitcase carry exercise with emphasis on posture control.

A typical exercise session consisted of a 10 min warm up, with 1 min rest in-between the above exercises, and a cool down period (10–15 min), totaling approximately 30 to 45 min of exercise, which was required to be undertaken as per the capability of the patients. Scaling and progression of exercise was key in the delivery of the plan. All exercise steps were developed to accommodate functional routines outside the gym, making them adaptable using common home-based accessories, for instance, a chair for squats or a water bottle for shoulder press.

The control group

For participants assigned to the control groups, community physicians/general practitioners advised them to engage in community-based exercise classes which a trained coach usually leads as per standard practice. For both groups, no exercise prescription was issued, and there was no guidance

or involvement of an exercise referral consultant. Typically, when patients are not properly guided through such exercise programmes, the enrolment and adherence tend to be quite poor; while patients undergoing pre-participation evaluations of both their physical and mental health status with individualized exercise interventions report high adherence (Collado-Mateo et al. 2021). In line with this, for a better representation of the effect of ERS on the anthropometric and physiological variables, the control group was subsequently merged for comparative analysis.

Anthropometric measurements and blood biomarkers

Physical and physiological variables were measured in all participants during the 20-week study (Table 1) by healthcare practitioners within the Mediclinic's or the AHCs. Blood samples were sent to the Central Health Laboratory of the Ministry of Health and Wellness and analysed as per established protocols. Participants were also administered a satisfaction survey to assess the perceived significance of ERS. The physical activity levels of participants were also evaluated using the Quick Physical Activity Rating (QPAR) Scale.

Data analysis

Data was compiled and analysed using both Microsoft Excel and IBM SPSS© statistical software. The choice of parametric and non-parametric tests was based on normality assessment undertaken through Shapiro–Wilk's test given its accuracy and stringency over Smirnov's test. The respective dependent variables were used and a cutoff value of $p < 0.05$ to identify deviations from normality. Descriptive data were reported through means and measures of dispersion. Repeated measures and one-way ANOVA were used to test for effects within the respective groups, i.e. the impact of exercise referral from the baseline measurements as indicated by day 0. The relevant corrections were applied using the Greenhouse–Geisser correction in conditions whereby sphericity was not assumed. Comparative analyses were also undertaken using day 0 as a baseline measurement and changes observed at week 10 and week 20 against the baseline measures within the intervention group as well as tested between the control and the treatment groups using the independent *t* tests or its non-parametric equivalent. Analyses within the individual groups were undertaken using paired *t* tests or its non-parametric homologous test.

Ethical considerations

All participants submitted a signed consent form attached to a comprehensive information sheet detailing the study objectives, design and projected outcomes of the study. The risks and benefits were clearly outlined and explained before enrolment in the study. To overcome any language barriers, the consent form and the information sheet was also available in French or translated into the preferred native language of the participant.

Before enrolment, a pre-briefing session was held to clarify any doubts. During this time, all participants were guaranteed confidentiality of the data collected, and the freedom to withdraw from the study at any point in time without justification. They were also assured that withdrawal or non-participation would not impact their medical care at the Mediclinics or AHCs. The study protocol was granted ethical clearance by the National Ethics Committee of the Ministry of Health and Wellness, Mauritius (Ref. MHC/CT/NETH/2022A).

Results

As per the final output post processing, 70% of participants remained throughout the study. Missing data points for either anthropometric measures of the participants at

Table 1 Anthropometric and physiological determinants recorded during the 20-week ERS

	Variable	Time-point	Remarks
Physical measurements	Weight, body mass index (BMI), waist circumference, grip strength	Week 0 week 10, and week 20	
NCD-related physiological measurements	Systolic and diastolic blood pressure, fasting blood glucose, HbA1C, total cholesterol, triglycerides	Week 0 week 10, and week 20	
Physical activity level assessment	Physical activity	Week 0 and week 20	Quick Physical Activity Rating scale (QPAR)-10 items to rate the intensity of different activities engaged in, frequency per week and duration per day
Satisfaction of participation	Satisfaction, experience, perception of health improvements	Week 20	Assessed via a self-administered questionnaire or via telephone

specific milestones because of participant's withdrawal or more than 5 weeks of absence consecutively were automatically removed from the study findings but allowed to continue with the project. Hence, 58 men and 129 women stayed within the programme until its completion at week 20; while 72 and 109 participants were retained in the intervention and treatment groups, respectively.

Participants' demographic profile and medical history

Most participants were women (68.1%), married (67.3%), had 1–2 children (53.8%), and 83.9% had a basic educational profile with a minimum of primary education (Table 2). Most participants earned less than Rs 30,000 (77.3%). Concerning pre-existing medical conditions, 44.2% were diagnosed with at least one risk factor for coronary heart disease (CHD), while only 3.5% presented four CHD risk factors. The most common risk factor identified was diabetes mellitus type 2 (80.9%) and in ranked order, hypertension, dyslipidaemia and obesity, with 59.1%, 54.8% and 17.4%, respectively.

Participants self-reported physical activity levels and adherence to ERS programme

Participants were asked to rate their physical activity level over a range of 1–10, with 1 demonstrating almost no activity while 10 was indicative of being highly engaged in physical activity, the outcome of which was an average of 5.68 ± 1.58 (mean $\pm$ SD) on the activity engagement spectrum; 32.4% estimated their activity level to be below the moderate profile, i.e. ≤ 5, while the remainder (67.6%) felt they were engaged in high activity levels with a self-rating of ≥ 6. Analysis of the activity profiles using the Quick Physical Activity Scale (QPAR) showed that an average of 70.5% of the respondents were not physically active across the different intensity profiles of activities. The data also revealed that only 15.6% of respondents were physically active for more than 3 days a week, while most participants did not

Table 2 Participants' characteristics at enrolment stage

Item	Descriptive	Frequency (n =)	Percentage (%)
Gender	Male	83	31.9
	Female	177	68.1
Marital status	Single	8	3.1
	Married	175	67.3
	Divorced	11	4.2
	Widowed	24	9.2
	Prefer not to say	42	16.2
Children	I don't have any	26	10.0
	1–2	140	53.8
	3 or more	69	26.5
	Prefer not to say	25	9.6
Educational level	Primary school	111	42.7
	Secondary school	107	41.2
	Tertiary	7	2.7
	Technical/professional qualifications	3	1.2
	Prefer not to say	32	12.3
Employment status	Not working/ currently unemployed	67	25.8
	Retired	63	24.2
	Student	2	0.8
	Employed part-time	22	8.5
	Employed full-time	83	31.9
	Prefer not to say	23	8.8
Income	Less than Rs 20,000	166	63.8
	Rs 20,001 to 30,000	35	13.5
	Rs 30,001 to 40,000	5	1.9
	Rs 40,001 to 50,000	5	1.9
	Prefer not to say	49	18.8

engage in moderate or strenuous activities, i.e. pitched at intensity level 2 or 3 (Supplementary Data S1).

The QPAR data was further computed to determine the physical activity score within the range of 0–153, a bandwidth denoting a higher participation in physical activity with higher scores across the spectrum. The mean score noted for the overall participants was 9.93 ± 5.7 (mean ± SD) nested with the category of 0–27. However, it is to be noted that the internal consistency for this particular scale was 0.474, which was lower than the expected alpha value of 0.7, and this could potentially be attributed to the complexity of the questions in terms of daily activities which could not be easily mapped through the lens of the average Mauritian household bearer. Women scored lower on the QPAR scale than men (9.31 ± 5.18 vs 11.74 ± 6.87; mean ± SD), data almost achieving significance level, $U = 374.5$, $p = 0.066$.

A comparative effect of ERS on participants across the 20-week programme

The normalized data for the overall intervention and control group were assessed for the benefits of the ERS; probing at both genders within an analytical cluster (Table 3). A net positive effect of the ERS was observed for both anthropometric and some physiological variables such as FBS, HBA1c, cholesterol and BMI, which is in line with the gendered differences observed, although this combined analysis might solely be due to the effect of the ERS observed in female participants.

Comparative tests between the control and intervention groups were undertaken at week 10 and week 20 to determine the efficiency of exercise referral after normalization of the data points against the baseline (day 0). The data computed were within the same pattern of comparison for men and women, with the latter exhibiting more overt differences in terms of improvements in blood parameters and anthropometric measures over the control group who were not prescribed any exercise; data supported mean a fold change of less than one.

Importantly, the results were stratified to address genetic and sex differences within each group and analysed accordingly for female (Table 4) and male (Table 5) groups. Marked differences between the control and the intervention group were observed at week 10 for weight [$t(111) = -2.442$, $p < 0.05$], waist circumference [$t(103) = -3.029$, $p < 0.01$], fasting blood sugar levels [$t(53) = -2.103$, $p < 0.05$], cholesterol levels [$t(70) = -3.138$, $p < 0.01$] and BMI [$t(97) = -2.432$, $p < 0.05$]; while parameters including HBA1c and triglyceride levels remained unchanged. At week 20, similar improvements were observed for the female intervention group for weight [$t(104) = -3.242$, $p < 0.01$], waist circumference [$t(100) = -4.018$, $p < 0.001$] and BMI [$t(94) = -3.655$, $p < 0.001$]; while HBA1c levels appeared to have improved only after 20-weeks of exercise [$t(45) = -2.572$, $p < 0.05$]. No significant differences were recorded between the two groups for triglyceride and cholesterol levels at week 20. Overall, exercise referral had a net positive effect on the female participants within

Table 3 Effect of 20-week ERS between control and treatment group at different timepoints

Parameters	Timepoint	Control		Intervention	
		Mean	SD	Mean	SD
Weight (kg)	Week 10	1.00	0.04	0.98*	0.03
	Week 20	0.99	0.04	0.97**	0.03
Waist circumference (cm)	Week 10	1.01	0.04	0.99**	0.03
	Week 20	1.01	0.06	0.96***	0.03
Fasting blood sugar (mmol/L)	Week 10	1.09	0.32	0.92*	0.23
	Week 20	0.98	0.16	0.98	0.18
HBA1c (%)	Week 10	1.33	1.70	0.94	0.10
	Week 20	1.01	0.09	0.94*	0.08
Cholesterol (mmol/L)	Week 10	1.03	0.18	0.88**	0.17
	Week 20	0.99	0.18	0.98	0.17
Triglyceride (mmol/L)	Week 10	1.20	1.12	1.15	0.50
	Week 20	1.15	1.12	0.99	0.38
BMI (Kg/m^2)	Week 10	1.00	0.04	0.98*	0.03
	Week 20	0.99	0.04	0.96***	0.03

Day 0 measurements taken as baseline data for normalization, data presented as fold change of mean values recorded at each time point for individual parameters assessed. Statistical significance against control group denoted at *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 4 Fold change in anthropometric and blood marker in female control versus intervention participants at 10 and 20 weeks

Parameters	Timepoint	Control		Intervention	
		Mean	SD	Mean	SD
Weight (kgs)	Week 10	1.00	0.04	0.98*	0.03
	Week 20	0.99	0.04	0.97**	0.03
Waist circumference (cms)	Week 10	1.01	0.04	0.99**	0.03
	Week 20	1.01	0.06	0.96***	0.03
Fasting blood sugar (mmol/L)	Week 10	1.09	0.32	0.92*	0.23
	Week 20	0.98	0.16	0.98	0.18
HBA1c (%)	Week 10	1.33	1.70	0.94	0.10
	Week 20	1.01	0.09	0.94*	0.08
Cholesterol (mmol/L)	Week 10	1.03	0.18	0.88**	0.17
	Week 20	0.99	0.18	0.98	0.17
Triglyceride (mmol/L)	Week 10	1.20	1.12	1.15	0.50
	Week 20	1.15	1.12	0.99	0.38
BMI (Kg/m^2)	Week 10	1.00	0.04	0.98*	0.03
	Week 20	0.99	0.04	0.96***	0.03

Day 0 measurements taken as baseline data for normalization, data presented as a fold change of mean values recorded at each time point for individual parameters assessed. Statistical significance against control group denoted at *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 5 Fold change in anthropometric and blood markers in male control versus intervention participants at 10 and 20 weeks

Parameters	Timepoint	Control		Intervention	
		Mean	SD	Mean	SD
Weight (kgs)	Week 10	1.01	0.05	0.99	0.03
	Week 20	0.99	0.03	0.98	0.03
Waist circumference (cms)	Week 10	1.00	0.03	0.98	0.04
	Week 20	1.00	0.04	0.97*	0.05
Fasting blood sugar (mmol/L)	Week 10	1.07	0.22	0.99	0.22
	Week 20	1.10	0.22	1.07	0.22
HBA1c (%)	Week 10	1.00	0.07	0.99	0.26
	Week 20	1.17	0.64	0.95	0.16
Cholesterol (mmol/L)	Week 10	1.04	0.16	1.09	0.27
	Week 20	0.97	0.16	0.97	0.22
Triglyceride (mmol/L)	Week 10	1.13	0.89	1.11	0.68
	Week 20	0.92	0.64	1.01	0.66
BMI (kg/m^2)	Week 10	1.01	0.05	0.99	0.03
	Week 20	0.99	0.03	0.98	0.03

Day 0 measurements taken as baseline data for normalization, data presented as fold change of mean values recorded at each time point for individual parameters assessed. Statistical significance against control group denoted at * $p < 0.05$

the intervention group yielding a significantly lower fold change than the control group at week 10. In some cases, the improvement extended till week 20.

Similarly, when the effect of exercise was examined across the male participants, a declining fold change was noted in most of the parameters being assessed, although statistical significance was not achieved, except for waist circumference at week 20 with a net reduction as opposed to the control group [$t(48) = -2.681$, $p < 0.05$] (Table 6). Given the declining trend of the data, a pairwise comparison using the normalized data was also generated, and data revealed significant differences between the weight [$t(18) = 2.449$, $p < 0.05$] and BMI [$t(18) = 2.449$, $p < 0.05$] when comparing week 10 versus week 20; while waist circumference nearly achieved significance [$t(15) = 1.910$, $p = 0.076$]. The present data supports the notion that female participants show more restraint and commitment towards the exercise referral programme than male participants.

Impact of ERS on anthropometric measures and blood biomarkers in the female intervention group

Data was segmented to provide insight into changes recorded within the intervention group, segregating male and female participants to minimize variations within the measured variables (Table 6). A positive response to the programme was found with a marked reduction in weight through pairwise comparisons between day 0 vs week 10 [$t(48) = 3.31$, $p < 0.01$], day 0 vs week 20 [$t(37) = 3.01$, $p < 0.01$], and week 10 versus week 20 [$t(40) = 2.49$, $p < 0.05$] (Table 3). Similar effects were noted for waist circumference: day 0 vs week 10 [$t(43) = 2.01$, $p < 0.05$], day 0 vs week 20 [$t(38) = 5.59$, $p < 0.001$], and week 10 versus week 20 [$t(34) = 4.79$, $p < 0.001$].

Regarding blood biomarkers, changes reported in FBS were significant only for the first milestone, i.e. day 0 vs week 10 [$t(21) = 2.48$, $p < 0.05$], while day 0 vs week 20 and week 10 versus week 20 resulted in no significant differences in fasting blood glucose levels. Contrastingly, HBA1c levels were significantly different across the whole study with day 0 as the benchmark measure: day 0 vs week 10 [$t(22) = 2.28$, $p < 0.05$] and day 0 vs week 20 [$t(18) = 2.8$, $p < 0.01$], with no marked differences recorded between week 10 versus week 20 ($p = 0.076$). Measured lipid levels demonstrated a significant change in cholesterol for day 0 vs week 10 [$t(21) = 2.99$, $p < 0.01$] and no reported changes for the other measurements; while triglyceride levels showed significant differences only between week 10 and week 20 [$t(13) = 2.39$, $p < 0.05$] (Table 3). A time-dependent decrease as a result of the exercise regimen implemented could be observed only for HBA1c [$F(2,4) = 25.0$, $p < 0.01$], while the remaining parameters remained unchanged.

With regard to body mass index (BMI), a net reduction in BMI was observed across the treatment group over 20 weeks with the data recorded at each timepoint consistently decreasing as follows, day $0 = 30.4 \pm 1.1$, week $10 = 29.92 \pm 1.18$ and week $20 = 29.38 \pm 1.2$ (data presented as mean ± SEM; BMI measured as kg/m^2). Non-parametric comparisons also confirmed the decrease among the different combinations, i.e. day 0 vs week 10 [$U = -2.88$, $p < 0.01$], day 0 vs week 20 [$U = -3.94$, $p < 0.001$], and week 10 versus week 20 [$U = -3.1$, $p < 0.01$].

Impact of ERS on anthropometric measures and blood biomarkers within the male intervention group

A significant contrast in the outcomes between male and female participants were observed. Anthropometric data such as weight and waist circumference significantly improved over time such that a decrease in weight and waist circumference was noted past the 10th week [weight: day 0 versus week 10 = no changes ($p > 0.05$), day 0 vs week 20 [$t(19) = 3.2$, $p < 0.01$], and week 10 versus week 20 [$t(16) = 2.26$, $p < 0.05$; waist circumference: day 0 versus week 10 = no changes ($p > 0.05$), day 0 vs week 20 [$t(16) = 2.5$, $p < 0.05$], and week 10 versus week 20 [$t(15) = 2.21$, $p < 0.05$] (Table 7). Pairwise comparisons did not yield any significant changes in the blood profile markers of the male participants. However, when treated as independent groups across the time points, a time-dependent

Table 6 Physical and physiological markers across the 20-week ERS in female participants

Parameter	Timepoint	Mean*	Std. deviation	Std. error mean
Weight (kg)	Day 0	71.6	14.5	2.1
	Week 10	70.5	15.5	2.2
	Week 20	69.4	18.6	2.9
Waist (cm)	Day 0	97.8	10.7	1.6
	Week 10	96.8	11.4	1.7
	Week 20	93.7	10.4	1.8
HBA1c (%)	Day 0	8.7	2.5	0.5
	Week 10	8.0	1.6	0.3
	Week 20	7.4	1.5	0.3
Fasting blood sugar (mmol/L)	Day 0	9.4	3.3	0.7
	Week 10	7.8	1.9	0.4
	Week 20	7.9	2.6	0.6
Cholesterol (mmol/L)	Day 0	5.2	1.1	0.2
	Week 10	4.5	0.9	0.2
	Week 20	4.4	0.8	0.2
Triglyceride (mmol/L)	Day 0	1.1	0.5	0.1
	Week 10	1.2	0.4	0.1
	Week 20	1.0	0.3	0.1
	Significance levels (p values)			
Variable	Day 0 versus week 10		Day 0 versus week 20	Week 10 versus week 20
Weight	0.002*		0.004*	0.017
Waist circumference	0.042*		0.000***	0.000***
HBA1c	0.032*		0.076	0.011*
FBS	0.022*		0.293	0.47
Cholesterol	0.007**		0.522	0.242
Triglycerides	0.709		0.356	0.033*

Data presented as p values from the paired t tests conducted, significance capped at *$p < 0.05$, **$p < 0.01$ and ***$p < 0.001$

effect based on the exercise regimen was observed for blood cholesterol [$F(2,38) = 11.77$, $p < 0.001$] and triglyceride levels [$F(2,38) = 32.84$, $p < 0.001$], reflecting a net decrease over time.

Regarding body mass index (BMI), a net reduction in BMI was also observed across this cohort over 20 weeks. The following BMI values were recorded: day $0 = 28.53 \pm 0.90$, week $10 = 27.95 \pm 0.84$ and week $20 = 27.69 \pm 0.83$ (data presented as mean ± SEM; BMI measured as kg/m^2). Parametric mean comparisons confirmed the decrease for week 10 versus week 20 only 10 [$t(16) = 2.55$, $p < 0.05$], while the other combinations remained unchanged.

Perceived benefits of the ERS

Most participants (75.1%) agreed that it was beneficial in managing their health. However, some respondents (8.1%) disagreed with the statement, stating that exercise referral programmes may not be beneficial for everyone; 64.9% were generally comfortable with the activities designed by the ERC. Conversely, a proportion of respondents (35.1%) expressed some level of disagreement or uncertainty about the appropriateness of the activities designed by the ERC; 2.9% strongly disagreed with the tailored activities, highlighting the importance of regular assessment of comfort levels and more open communication between the relevant stakeholders; 64.5% indicated a strong likelihood of sustaining their prescribed physical workout routines post-programme. Overall, the ERS was rated between good to excellent by 72.1% of the participants and 91.4% confirmed that it met their needs while strongly supporting the role of the ERC (92.5%) in the whole process.

Discussion

In the present study, we report the effect of an ERS on health measures, using a well-defined participant cohort and study design and employing the recognized clinical criteria for hyperglycaemia, hypertension, dyslipidaemia, and elevated body mass index. For both male and female participants, at 20 weeks, we found an effect of the ERS on weight, waist

Table 7 Physical and physiological markers across the 20-week ERS in male participants

Parameter	Timepoint	Mean	Std. deviation	Std. error mean
Weight (kg)	Day 0	82.0	12.4	2.8
	Week 10	81.1	12.3	2.8
	Week 20	80.0	12.7	2.8
Waist (cm)	Day 0	100.5	8.9	2.1
	Week 10	99.2	8.9	2.1
	Week 20	97.0	7.6	1.9
HBA1c (%)	Day 0	8.5	1.0	0.3
	Week 10	8.5	1.7	0.6
	Week 20	7.8	1.6	0.6
Fasting blood sugar (mmol/L)	Day 0	8.8	3.2	1.1
	Week 10	8.3	2.4	0.8
	Week 20	8.5	1.9	0.7
Cholesterol (mmol/L)	Day 0	3.9	1.1	0.4
	Week 10	4.1	0.9	0.3
	Week 20	4.2	1.2	0.4
Triglyceride (mmol/L)	Day 0	2.2	1.2	0.4
	Week 10	1.7	1.1	0.4
	Week 20	1.6	0.9	0.3
	Significance levels (p values)			
Variable	Day 0 versus week 10		Day 0 versus week 20	Week 10 versus week 20
Weight	0.095		0.024*	0.002**
Waist circumference	0.166		0.022*	0.043*
HBA1c	0.571		0.178	0.373
FBS	0.587		0.668	0.723
Cholesterol	0.466		0.320	0.963
Triglycerides	0.928		0.472	0.866

Data presented as p values from the paired t tests conducted, significance capped at *$p < 0.05$ and **$p < 0.01$

circumference and BMI. For women, we found a significant effect on blood biomarkers, and a net decrease for the men over time. Our research coincides with a wealth of data to suggest that, despite implementation variations, ERS constitutes a vital component of preventive medicine, serving as a crucial intervention to mitigate the risk of lifestyle diseases and their complications (Albert et al. 2020). Our results indicate that a successful ERS can be implemented to effect change in health markers and justifies further research to overcome the noticeable gap in research on ERS implementation in the region of Africa.

The design of the 20-week exercise referral scheme was based on past studies demonstrating the typical exercise regimen spanning 2–27 weeks with a positive reported effect on NCD management as well as maintaining a good adherence index among participants (Tao et al. 2023). When comparing reasons for referral in countries such as Sweden, Australia, the UK and USA it is evident that cardiovascular diseases, psychological illnesses, musculoskeletal disorders and ageing are the most prevailing non-communicable concerns (Albert et al. 2020). Numerous community-based exercise referral schemes have been established across Europe and Northern America. Despite differences in research methodologies, using a Quality Assessment Tool (QATSDD) score by Albert et al. (Albert et al. 2020) enabled the evaluation of 27 physical activity referral schemes conducted across eight countries. Their study concluded that despite variations, ERS constitutes a vital component of preventive medicine, serving as a crucial intervention to mitigate the risk of lifestyle diseases and their complications. Indeed, the greater benefits of physical activity on the wellbeing of individuals has been advocated through numerous studies, implying its potency as a 'natural' medicine for NCDs (Saqib et al. 2020). Furthermore, it has been observed that patients are more likely to trust and adhere to physical activity advised by a health practitioner and monitored by an exercise referral instructor, rather than alternate sources to better manage their health conditions (Moore et al. 2011). In line with the outcome of the results of our control group, reliance solely on counselling and advice from general practitioners proves to be inadequate to motivate participants to actively participate in regular physical activity. Moreover, a consistent

finding in literature is that men are less likely than women to join an exercise referral scheme (Hanson et al. 2019). We report a similar trend, where women outnumbered men in terms of participation and with an adhered rate at week 20. Studies investigating the predictors of ERS uptake show that older women, with good mental health, and living in less deprived areas were more engaged (Shore et al. 2021; Morgan et al. 2020; Portman et al. 2023). Research by Tudor et al. (Tudor et al. 2021) suggests that weight loss in men could be more pronounced in those who are more consistently engaged in the exercise scheme, similar to their female counterparts. Therefore, to enhance appeal, engagement and address possible gender disparity, Tudor et al. (Tudor et al. 2021) recommend endorsement of gender-tailored programmes by general practitioners. This suggestion offers valuable insight for countries considering the implementation of exercise referral schemes.

In the present study, we report significant alterations in HbA1c and fasting blood sugar levels for women. A meta-analysis by Umpierre et al. (Umpierre et al. 2011) revealed that structured exercise exceeding 150 min per week for a 12-week duration resulted in better reductions in HbA1c levels (−0.89% vs −0.36%), where higher intensity workouts also produced better cardiovascular fitness outcomes (Boulé et al. 2003). Our findings were also in alignment with de Lade et al. (Lade et al. 2016), reporting a decrease in HbA1c levels in patients assigned to an exercise group, following a similar pattern to those undergoing treatment with metformin. However, similar findings were not reflected in the male counterparts, the latter which could be addressed by several inherent and external factors. Research conducted by MacDonald et al. (MacDonald et al. 2020) shed light on the impediments posed by dietary and metabolic trends of individuals which could hinder the body's ability to respond to exercise training. Aberrant mechanical signalling in muscles, modifications of the extracellular matrix and impaired vascularization in response to exercise in humans with impaired glucose tolerance was reported. The lack of meaningful improvements following a short-term exercise regime could potentially discourage individuals from adhering to exercise, resulting in reduced adherence to schemes and a diminished sense of motivation to continue post scheme (Eynon et al. 2019), advocating on the need to report noticeable changes both at anthropometric and physiological levels to enhance confidence in such programmes. This also shares important implications at a national level given that the risk of mortality and morbidity due to heart disease, stroke, blindness and kidney failure are significantly higher in individuals with diabetes. In 2021, its impact on quality of life accounted for 4.3% of deaths and a staggering 148.7 million USD of total expenditure in Mauritius. A cost forecasted to drop by a mere 4.4% in 2045 (International Diabetes Federation (IDF) Diabetes Atlas 2021). Treatment goals for individuals with diabetes include lifestyle changes, such as exercise along with diet and weight control. Epidemiological evidence suggests that endurance aerobic exercise over a prolonged period can assist with achieving an optimum glycaemic control (Syeda et al. 2023; Adams 2013). Adopting a holistic disease management programme with the inclusion of exercise prescription may lead to long-term positive impacts on the overall health of the individuals and reduce the cost per patient for comorbidities associated with poor NCD management.

Although our findings from Tables 5 and 7 suggest that men exhibited a delayed onset of initial changes compared to women, data from Mann et al. (Mann et al. 2014) suggest that aerobic exercise has a notable influence on the cholesterol levels, complementing findings by Albarrati et al. (Albarrati et al. 2018), stressing the net positive effect of exercise on cholesterol levels reduction. Quantitative alterations in serum lipids, including HDL particle maturation, composition and functionality, have been extensively reviewed by Franczyk et al. (Franczyk et al. 2023). Engagement in moderate-intensity aerobic exercise for 75 to 300 min per week is suggested to favour a significant change in body composition (Sarzynski et al. 2015). However, the findings of Wood et al. (Wood et al. 2019) contradict this, suggesting that high-intensity continuous training exerted a more favourable effect on lipid profile. Apart from the quantity of exercise, some authors also suggest that older adults may necessitate longer periods and more distinct physical activity approaches to achieve an improved HDL-C profile (King et al. 1995) as concomitant therapies, alcohol intake, consumption of omega-2 fatty acids and polyunsaturated fats have been documented to influence HDL-C levels by 4–12% (Siri-Tarino 2011). The controlled trial of Edwards et al. (Edwards et al. 2013) revealed that a 16-week national ERS was cost-saving and cost-effective in fully adherent participants with mental health and coronary heart diseases risk factors.

Evaluating participant satisfaction is a crucial aspect of an exercise referral programme as it provides insight into the programme's effectiveness and whether it is meeting the needs of the individuals it serves. This feedback can be used to identify areas where the programme can be improved, such as exercise routines, scheduling or overall programme structure (NCSEM 2020). More importantly, it can be used to design better strategies for improving participant engagement and motivation. An ERS that gathers favourable feedback from its participants is more likely to witness increased engagement and adherence levels. The present findings showed that participants responded positively to the ERS programme, with good satisfaction levels recorded. Overall, the data suggest that the exercise referral programme positively impacted managing health for most participants, but individual experiences may vary. Since the exercise referral

consultants (ERC) work closely with participants, this individualized approach ensures that participants are engaging in safe and effective exercises that are appropriate for their fitness level and health condition. Their role also extends to inspiring and assisting them in remaining engaged and dedicated to the programme. As highlighted in work by Shore et al. (2019), ERCs and physical activity instructors have a central and multifaceted responsibility in facilitating the adoption, attendance and compliance with exercise referral programmes. Researchers such as Markland and Tobin (2010) and Weman-Josefsson et al. (2015) also argue that the psychological needs of participants enrolled should not be overlooked. This ongoing support and guidance can be instrumental in helping participants achieve their health and fitness goals – hence greatly influencing the overall success of an exercise referral scheme. It is interesting to note that a relatively large proportion of participants (64.9%) were very likely to maintain their exercise routine even after the end of the programme, which mandates further longitudinal studies to map the sustained progress of those participants. Even after it has ended, high levels of adherence to the exercise regime suggest that the programme met the needs and preferences of a good proportion of its participants and that the exercise plans were deemed safe, effective and enjoyable. On the basis of the data presented, it appears that most respondents had a positive perception of the programme (75.1%).

Several exercise referral schemes and controlled exercise intervention trials have been associated with meaningful changes in health and wellbeing, including physical activity levels in NCD risk individuals (Zampogna et al. 2020; Rowley et al. 2020). In the present exercise intervention scheme, the QPARS tool was utilised to gauge the physical activity levels of our study population which resulted in very little engagement in physical activity within the sample surveyed. However, it is to be noted that the internal consistency for this scale was 0.474, which was lower than the expected alpha value of 0.7 as reported by Galvin et al. (2020), and this could potentially be attributed to the complexity of the questions in terms of daily activities which could not be easily mapped through the lens of the average Mauritian household bearer. Furthermore, potentially impacting the terminologies used during the survey, almost 60% of the participants were retired or unemployed, with the highest academic achievement being secondary educational level. Although we developed the intervention to address a complex interplay of various elements ranging from individual health characteristics to socio-economic factors, these may have influenced the expected health outcomes in our study population.

The observed disparity between the outcomes of men and women within the intervention group of our study raises the possibility that a complex interplay of various elements ranging from individual health characteristics to socio-economic factors may have influenced the expected health outcomes in our study population. The study of Birtwistle et al. (2019), which drew upon Bronfenbrenner's socio-ecological model, further undercovers a multitude of factors operating at intrapersonal, intrapersonal, organizational and environmental levels which could interplay and influence ERS engagement. Individual attitudes, personal goals and knowledge of health and exercise, supportive and non-judgmental encouragement, the proximity of local facilities, and the availability of local transportation were all major influencers (Birtwistle et al. 2019). Some researchers also contend that inequalities in the built environment underlie health-relevant disparities in physical activity. Social determinants, such as the absence or lack of access to sports facilities in underserved areas could reinforce the participation gap observed between poor or affluent areas, influenced by individual factors such as education and income levels (Vandermeerschen et al. 2017). The correlations between these factors were not investigated in the current study, but warrant further exploration to better understand their potential influence in the Mauritian context.

Literature on physical activity interventions has consistently indicated a positive impact on modulating a range of health problems, including obesity, heart disease and diabetes (Paluch et al. 2023; Oguma and Shinoda-Tagawa 2004). However, contentious findings from studies conducted by Morgan et al. (2020) and Craike et al. (2019) uncovered a degree of hesitancy among healthcare practitioners when it comes to referring patients to ERS, which contrasted with surveys such as Sharma et al. (2012) which showed patients exhibit a positive attitude towards the concept of exercise referral schemes. Such behaviour can be interpreted as contributing to health inequity. Moreso, government-supported ERS implemented in economically disadvantaged areas are cheaper and have greater accessibility and acceptability by patients in those areas (Craike et al. 2018). Future research will involve a closer examination of the demographic profile of participants.

Limitations and future research

In accordance with the recent recommendations of the NCD survey report (International Diabetes Federation (IDF) Diabetes Atlas 2021) put forward by the Ministry of Health and Wellness on the implementation of exercise referral schemes in Mauritius, there remains a significant lack of health promotion efforts highlighting the benefits of exercise referral schemes in Mauritius. The same deduction resonates across the region of Africa. Addressing this gap through targeted awareness programmes could foster a culture of proactive health management and preventive care within the region. On the basis of the outcomes of Britwistle et al. (2019), the findings advocate initiatives to boost awareness regarding

community-based ERS and equally emphasize the importance of improving communication channels between referring practitioners and patients. Positive social interactions from health practitioners and exercise referral consultants contribute to creating a reassuring environment, where the patient feels more emotionally supported during the ERS journey. Therefore, the integration of technology such as mobile health devices and mobile applications to track data, create reminders and share work-out timetables or personal progress within app-specific communities or networking platforms should be considered as means to enhance social support, communication and adherence (Collado-Mateo et al. 2021). Further exploration into the role of health promotion, health care providers and family support systems in an ERS in the Mauritian context is warranted.

This study was conducted on a small subset of patients attending local public healthcare services. The small size of the cohort limits generalizability from various population subsets, such as age, race or socio-economic status. Moreover, the data collection period for the study coincided with the annual festive season, a time when a customary decline in physical activity adherence and NCD management are generally observed. This non-compliance, potentially influenced by holiday stress, overindulgence in high calorific foods and alcohol consumption during the festive season, may have contributed to the limited impact of the exercise intervention (Fahey et al. 2019; Abdulan et al. 2023). Further exploration into the role of health promotion, health care providers and family support systems in an ERS in the Mauritian context is warranted. Finally, research is also warranted to explore the effect of ERS across a broader range of pathologies for a more nuanced understanding of its effectiveness in varied medical contexts.

Conclusion

The study aimed to investigate the effectiveness of a 20-week exercise referral scheme which used local physical activity and sports resources on parameters of diabetes, hypertension and obesity among Mauritian adults. The programme was aligned with the Mauritian government's initiatives to improve the health and quality of life of those with non-communicable diseases. On the basis of the outcomes of female participants, both within group diagnostics and across group comparison, the data strongly supports the beneficial effects of exercise referral schemes as part of a management strategy to control non-communicable diseases. Our findings concur with literature stating that prolonged exercise referral programmes do bear significant outcomes and promote behavioural changes. Participants typically need time to establish a regular exercise routine, build confidence in their ability to exercise and develop healthy habits that they can maintain over the long term; this can be motivated by an ERC. Future exercise referral schemes should consider these factors for more successful health outcomes during design and planning. Exercise prescription thus emerges as a promising tool, capable of reshaping current healthcare approaches in Mauritius, fostering a more active and healthier population. Mauritius, as part of a newly transitioned UMIC and African country, can inspire other countries with similar demographics to unlock the potential of sport and physical activity to improve citizens' health and promote sustainable economic and social development.

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Author contribution AB designed, gained ethical approval and led the overall project, leading up to the write up and editing of the manuscript. JS & MP contributed in the study design, led the data analysis and led the manuscript writing. RL contributed to the design and coordination of the study. DG, DCJR, SS and RC reviewed the manuscript. All authors approved the final version of the manuscript for submission.

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Data availability The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

Declarations

Ethics approval The study protocol was reviewed and approved by the National Ethics Committee of the Ministry of Health and Wellness under approval number MCH/CT/NETH/2022. All participants provided informed consent, and their rights, privacy and confidentiality were strictly protected throughout the research process.

Patient and public involvement statement This project was based around the acceptability of a new intervention as a treatment method. Although PPI was not included prior to the project, the value-based questionnaire used enabled us to gain thoughts and opinions from participants and practitioners on the acceptability of using the exercise referral in the public health care sector. This will trigger the use of PPI in health care technology assessment in Mauritius in the future in this area.

Conflict of interest RL is employed as a medical practitioner by the Ministry of Health and Wellness. All other authors declare no conflict of interest.

References

Abdulan IM, Popescu G, Maștaleru A, Oancea A, Costache AD, Cojocaru DC, Cumpăt CM, Ciuntu BM, Rusu B, Leon MM (2023) Winter holidays and their impact on eating behavior-a systematic review. Nutrients 15(19):4201. https://doi.org/10.3390/nu15194201

Active Mauritius (2019) The national sport and physical activity policy for the republic of Mauritius. Available at: https://www.active-mauritius.com/wp-content/uploads/2019/07/National-Sport-and-Physical-Activity-Policy.pdf. Accessed 2 Jan 2024

Adams OP (2013) The impact of brief high-intensity exercise on blood glucose levels. Diabetes Metab Syndr Obes 6:113–122. https://doi.org/10.2147/DMSO.S29222

Albarrati AM, Alghamdi MSM, Nazer RI, Alkorashy MM, Alshowier N, Gale N (2018) Effectiveness of low to moderate physical exercise training on the level of low-density lipoproteins: a systematic review. Biomed Res Int 1(2018):5982980. https://doi.org/10.1155/2018/5982980

Albert FA, Crowe MJ, Malau-Aduli AEO, Malau-Aduli BS (2020) Functionality of Physical Activity Referral Schemes (PARS): a systematic review front. Public Health 8:257. https://doi.org/10.3389/fpubh.2020.00257

American Diabetes Association (2022) Standards of medical care in diabetes—2022 abridged for primary care providers. Clin Diabetes 40(1):10–38. https://doi.org/10.2337/cd22-as01

Birtwistle SB, Ashcroft G, Murphy R, Gee I, Poole H, Watson PM (2019) Factors influencing patient uptake of an exercise referral scheme: a qualitative study. Health Educ Res 34(1):113–127. https://doi.org/10.1093/her/cyy038

Boulé NG, Kenny GP, Haddad E, Wells GA, Sigal RJ (2003) Meta-analysis of the effect of structured exercise training on cardiorespiratory fitness in type 2 diabetes mellitus. Diabetologia 46(8):1071–1081. https://doi.org/10.1007/s00125-003-1160-2

Brysbaert M (2019) How many participants do we have to include in properly powered experiments? A tutorial of power analysis with reference tables. J Cogn 2:16. https://doi.org/10.5334/joc.72

Burns A, Wallot S, Berson Y, Gordon I (2022) Dataset of physiological, behavioral, and self-report measures from a group decision-making lab study. Data Brief 45:108630. https://doi.org/10.1016/j.dib.2022.108630

Cashin AG, Booth J, McAuley JH, Jones MD, Hübscher M, Traeger AC, Fried K, Moseley GL (2022) Making exercise count: considerations for the role of exercise in back pain treatment. Musculoskeletal Care 20(2):259–270. https://doi.org/10.1002/msc.1597

Cavallo FR, Golden C, Pearson-Stuttard J, Falconer C, Toumazou C (2022) The association between sedentary behaviour, physical activity and type 2 diabetes markers: a systematic review of mixed analytic approaches. PLoS ONE 17(5):e0268289. https://doi.org/10.1371/journal.pone.0268289

Collado-Mateo D, Lavín-Pérez AM, Peñacoba C, Del Coso J, Leyton-Román M, Luque-Casado A, Gasque P, Fernández-del-Olmo MÁ, Amado-Alonso D (2021) Key factors associated with adherence to physical exercise in patients with chronic diseases and older adults: an umbrella review. Int J Environ Res Public Health 4:2023

Craike M, Wiesner G, Enticott J, Bennie JA, Biddle SJH (2018) Equity of a government subsidised exercise referral scheme: a population study. Soc Sci Med 216:20–25. https://doi.org/10.1016/j.socscimed.2018.09.023

Craike M, Britt H, Parker A, Harrison C (2019) General practitioner referrals to exercise physiologists during routine practice: a prospective study. J Sci Med Sport 22(4):478–483. https://doi.org/10.1016/j.jsams.2018.10.005

de Lade CG, Marins JC, Lima LM, de Carvalho CJ, Teixeira RB, Albuquerque MR, Reis JS, Amorim PR (2016) Effects of different exercise programs and minimal detectable changes in hemoglobin A1c in patients with type 2 diabetes. Diabetol Metab Syndr 8:1–9. https://doi.org/10.1186/s13098-016-0123-y

Edwards RT, Linck P, Hounsome N, Raisanen L, Williams N, Moore L, Murphy S (2013) Cost-effectiveness of a national exercise referral programme for primary care patients in Wales: results of a randomised controlled trial. BMC Public Health 3:1021. https://doi.org/10.1186/1471-2458-13-1021

Eynon M, Foad J, Downey J, Bowmer Y, Mills H (2019) Assessing the psychosocial factors associated with adherence to exercise referral schemes: a systematic review. Scand J Med Sci Sports 29:638–650. https://doi.org/10.1111/sms.13403

Fahey MC, Klesges RC, Kocak M, Wang J, Talcott GW, Krukowski RA (2019) Do the holidays impact weight and self-weighing behaviour among adults engaged in a behavioural weight loss intervention? Obes Res Clin Pract 13(4):395–397. https://doi.org/10.1016/j.orcp.2019.05.001

Franczyk B, Gluba-Brzozka A, Cialkowska Rysz A et al (2023) The impact of aerobic exercise on HDL quantity and quality: a narrative review. Int J Mol Sci 24(5):4653. https://doi.org/10.3390/ijms24054653

Galvin JE, Tolea MI, Rosenfeld A, Chrisphonte S (2020) The Quick Physical Activity Rating (QPAR) scale: a brief assessment of physical activity in older adults with and without cognitive impairment. PLoS ONE 15(10):e0241641. https://doi.org/10.1371/journal.pone.0241641

Garcia L, Mendonça G, Benedetti TRB, Borges LJ, Streit IA, Christofoletti M, Silva-Júnior FLE, Papini CB, Binotto MA (2022) Barriers and facilitators of domain-specific physical activity: a systematic review of reviews. BMC Public Health 22:1964. https://doi.org/10.1186/s12889-022-14385-1

Gelius P, Messing S, Goodwin L, Schow D, Abu-Omar K (2020) What are effective policies for promoting physical activity? A systematic review of reviews. Prev Med Rep 18:101095. https://doi.org/10.1016/j.pmedr.2020.101095

Gibbs B, Hivert MF, Jerome GJ, Kraus WE, Rosenkranz SK, Schorr EN, Spartano NL, Lobelo F; American Heart Association Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular and Stroke Nursing; and Council on Clinical Cardiology (2021) Physical activity as a critical component of first-line treatment for elevated blood pressure or cholesterol: who, what, and how?: A scientific statement from the American heart association. Hypertension 78(2):e26-e37. https://doi.org/10.1161/HYP.0000000000000196

González K, Fuentes J, Márquez JL (2017) Physical inactivity, sedentary behavior and chronic diseases. Korean J Fam Med 38(3):111–115. https://doi.org/10.4082/kjfm.2017.38.3.111

Hakami SM, Omar MT, Alsaad SM, Vennu VS, Hattan LI, Bindawas SM (2023) Association between non-communicable diseases and physical activity level in older adults visiting primary health

care centers in Jizan, Saudi Arabia. Saudi Med J 44(6):580–587. https://doi.org/10.15537/smj.2023.44.6.20230076
Hanson C, Oliver E, Dodd-Reynolds C, Allin L (2019) How do participant experiences and characteristics influence engagement in exercise referral? A qualitative longitudinal study of a scheme in Northumberland, UK. BMJ Open 9(2):e024370
International Diabetes Federation (IDF) Diabetes Atlas (2021) Mauritius diabetes Report 2000-2045. Available at: https://diabetesatlas.org/data/en/country/127/mu.html. Accessed 2 Jan 2024
King AC, Haskell WL, Young DR, Oka RK, Stefanick ML (1995) Long-term effects of varying intensities and formats of physical activity on participation rates, fitness, and lipoproteins in men and women aged 50 to 65 years. Circulation 91:2596–2604. https://doi.org/10.1161/01.cir.91.10.2596
Liang ZD, Zhang M, Wang CZ, Yuan Y, Liang JH (2022) Association between sedentary behavior, physical activity, and cardiovascular disease-related outcomes in adults-a meta-analysis and systematic review. Front Public Health 10:1018460. https://doi.org/10.3389/fpubh.2022.1018460
MacDonald TL, Pattamaprapanont P, Pathak P et al (2020) Hyperglycaemia is associated with impaired muscle signalling and aerobic adaptation to exercise. Nat Metab 2:902–917. https://doi.org/10.1038/s42255-020-0240-7
Mach F, Baigent C, Catapano AL, Koskinas KC, Casula M, Badimon L, Chapman MJ, De Backer GG, Delgado V et al (2020) ESC/EAS guidelines for the management of dyslipidaemias: lipid modification to reduce cardiovascular risk. Eur Heart J 41(1):111–188. https://doi.org/10.1093/eurheartj/ehz455
Mann S, Beedie C, Jimenez A (2014) Differential effects of aerobic exercise, resistance training and combined exercise modalities on cholesterol and the lipid profile: review, synthesis and recommendations. Sports Med 44:211–221. https://doi.org/10.1007/s40279-013-0110-5
Markland D, Tobin VJ (2010) Need support and behavioural regulations for exercise among exercise referral scheme clients: the mediating role of psychological need satisfaction. Psychol Sports Exer 11(2):91–99. https://doi.org/10.1016/j.psychsport.2019.03.007
Moore GF, Moore L, Murphy S (2011) Facilitating adherence to physical activity: exercise professionals' experiences of the National Exercise Referral Scheme in Wales. a qualitative study. BMC Public Health 11:935. https://doi.org/10.1186/1471-2458-11-935
Morgan K, Rahman M, Moore G (2020) Patterning in patient referral to and uptake of a National Exercise Referral Scheme (NERS) in Wales from 2008 to 2017: a data linkage study. Int J Environ Res Public Health 17(11). https://doi.org/10.3390/ijerph17113942
National Action Plan on Physical Activity 2011–2014 (2011) Available at: https://health.govmu.org/health/wp-content/uploads/2023/03/National-Action-Plan-on-Physical-Activity-2011-2014.pdf. Accessed 2 Jan 2024
National Institute for Health and Care Excellence (NICE) (2014) Physical activity: exercise referral schemes Public health guideline [PH54] Available at: https://www.nice.org.uk/guidance/ph54. Accessed 2 Jan 2024
National Sport and Physical Activity Policy for the Republic of Mauritius (2018-2028). Available at: https://www.active-mauritius.com/wp-content/uploads/2019/07/National-Sport-and-Physical-Activity-Policy.pdf. Accessed 2 Jan 2024
NCSEM (2020) A toolkit for the design, implementation and evaluation of exercise referral schemes. Available at: https://ncsem-em.org.uk/wp-content/uploads/2020/10/section-8-evaluating-exercise-referral-schemes.pdf. Accessed 2 Jan 2024
O'Brien MW, Bray NW, Kivell MJ, Fowles JR (2021) A scoping review of exercise referral schemes involving qualified exercise professionals in primary health care. Appl Physiol Nutr Metab 46(9):1007–1018. https://doi.org/10.1139/apnm-2020-1070
Oguma Y, Shinoda-Tagawa T (2004) Physical activity decreases cardiovascular disease risk in women: review and meta-analysis. Am J Prev Med 26(5):407–418
Paluch AE, Bajpai S, Ballin M, Bassett DR, Buford TW, Carnethon MR et al (2023) Steps for health collaborative. Prospective association of daily steps with cardiovascular disease: a harmonized meta-analysis. Circulation 147(2):122–131
Portman RM, Levy AR, Allen SF, Fairclough SJ (2023) Exercise referral scheme participant characteristics, referral mode and completion status. Health Educ J 82(3):311–323. https://doi.org/10.1177/00178969231156108
Reiner M, Niermann C, Jekauc D, Woll A (2013) Long-term health benefits of physical activity – a systematic review of longitudinal studies. BMC Public Health 13:813. https://doi.org/10.1186/1471-2458-13-813
Rowley N, Steele J, Wade M, Copeland RJ, Mann S, Liguori G, Horton E, Jimenez A (2020) Are exercise referral schemes associated with an increase in physical activity? observational findings using individual patient data meta-analysis from the national referral database. J Phys Act Health 17(6):621–631. https://doi.org/10.1123/jpah.2019-0435
Rowley N, Mann S, Steele J, Horton E, Jimenez A (2018) The effects of exercise referral schemes in the United Kingdom in those with cardiovascular, mental health, and musculoskeletal disorders: a preliminary systematic review. BMC Public Health 18:949. https://doi.org/10.1186/s12889-018-5868-9
Saqib ZA, Dai J, Menhas R, Mahmood S, Karim M, Sang X, Weng Y (2020) Physical activity is a medicine for non-communicable diseases: a survey study regarding the perception of physical activity impact on health wellbeing. Risk Manag Healthc Policy 11(13):2949–2962
Sarzynski MA, Burton J, Rankinen T, Blair SN, Church TS, Després J-P, Hagberg JM, Landers-Ramos R, Leon AS, Mikus CR et al (2015) The effects of exercise on the lipoprotein subclass profile: a meta-analysis of 10 interventions. Atherosclerosis 243:364–372. https://doi.org/10.1016/j.atherosclerosis.2015.10.018
Saunders TJ, McIsaac T, Douillette K, Gaulton N, Hunter S, Rhodes RE, Prince SA, Carson V, Chaput JP, Chastin S, Giangregorio L, Janssen I, Katzmarzyk PT, Kho ME, Poitras VJ, Powell KE, Ross R, Ross-White A, Tremblay MS, Healy GN (2020) Sedentary behaviour and health in adults: an overview of systematic reviews. Appl Physiol Nutr Metab 45(10 (Suppl. 2)):S197-S217. https://doi.org/10.1139/apnm-2020-0272
Sharma H, Bulley C, van Wijck FM (2012) Experiences of an exercise referral scheme from the perspective of people with chronic stroke: a qualitative study. Physiotherapy 98(4):336–343. https://doi.org/10.1016/j.physio.2011.05.004
Shore C, Hubbard G, Gorely T, Hunter A, Polson R, Galloway SD (2019) Insufficient reporting of factors associated with exercise referral scheme uptake, attendance, and adherence: a systematic review of reviews. J Phys Act Health 16(8):667–676. https://doi.org/10.1123/jpah.2018-0341
Shore CB, Galloway SDR, Gorely T, Hunter AM, Hubbard G (2021) Exercise referral instructors' perspectives on supporting and motivating participants to uptake, attend and adhere to exercise prescription: a qualitative study. Int J Environ Res Public Health 19(1):203. https://doi.org/10.3390/ijerph19010203
Siri-Tarino PW (2011) Effects of diet on high-density lipoprotein cholesterol. Curr Atheroscler Rep 13:453–460. https://doi.org/10.1007/s11883-011-0207-y
Stathi A, McKenna J, Fox KR (2004) The experiences of older people participating in exercise referral schemes. J R Soc Promot Health 124(1):18–23. https://doi.org/10.1177/146642400312400108
Syeda USA, Battillo D, Visaria A, Malin SK (2023) The importance of exercise for glycemic control in type 2 diabetes. Am J Med Open 9:(100031). https://doi.org/10.1016/j.ajmo.2023.100031

Tao X, Chen Y, Zhen K, Ren S, Lv Y, Yu L (2023) Effect of continuous aerobic exercise on endothelial function: a systematic review and meta-analysis of randomized controlled trials. Front Physiol 14:1043108

The Commonwealth (2018) Sport reforms in Mauritius attract Commonwealth experts. Available at https://thecommonwealth.org/news/sport-reforms-mauritius-attract-commonwealth-experts. Accessed 2 Jan 2024

The Commonwealth (2019) Sport reforms in Mauritius attract Commonwealth experts. Available at https://thecommonwealth.org/news/sport-reforms-mauritius-attract-commonwealth-experts

The Mauritius Non Communicable Diseases Survey (2021) Available at: https://files.aho.afro.who.int/afahobckpcontainer/production/files/Mauritius-Non-Communicable-Diseases-Survey-2021.pdf. Accessed 2 Jan 2024

Tomlinson-Perez S, Machaczek KK, Firth J et al (2022) Evaluation of the uptake, retention and effectiveness of exercise referral schemes for the management of mental health conditions in primary care: a systematic review. BMC Public Health 22:249. https://doi.org/10.1186/s12889-022-12638-7

Tudor K, Tearne S, Jebb SA, Lewis A, Adab P, Begh R, Jolly K, Daley A, Farley A, Lycett D, Nickless A, Aveyard P (2021) Gender differences in response to an opportunistic brief intervention for obesity in primary care: data from the BWeL trial. Clin Obesit 11(1):e12418. https://doi.org/10.1111/cob.12418

Umpierre D, Ribeiro PA, Kramer CK, Leitão CB, Zucatti AT, Azevedo MJ, Gross JL, Ribeiro JP, Schaan BD (2011) Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes: a systematic review and meta-analysis. JAMA 305(17):1790–2179. https://doi.org/10.1001/jama.2011.576

Vandermeerschen H, Van Regenmortel T, Scheerder J (2017) 'There are alternatives, but your social life is curtailed': poverty and sports participation from an insider perspective. Soc Indic Res 133(1):119–138. https://doi.org/10.1007/s11205-016-1360-z

Wade M, Mann S, Copeland RJ, Steele J (2020) Effect of exercise referral schemes upon health and well-being: initial observational insights using individual patient data meta-analysis from the national referral database. J Epidemiol Commun Health 74:32–41. https://doi.org/10.1136/jech-2019-212674

Weman-Josefsson K, Lindwall M, Ivarsson A (2015) Need satisfaction, motivational regulations and exercise: moderation and mediation effects. Int J Behav Nutr Phys Act 12:67. https://doi.org/10.1186/s12966-015-0226-0

WHO (2018) Global action plan on physical activity 2018–2030: more active people for a healthier world. Geneva: World Health Organization. Licence: CC BY-NC-SA 3.0 IGO. Accessible at: https://www.who.int/publications/i/item/9789241514187. Accessed 2 Jan 2024

Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, Clement D et al (2018) Practice guidelines for the management of arterial hypertension of the European society of cardiology and the European society of hypertension. Blood Press 6:314–340. https://doi.org/10.1080/08037051.2018.1527177

Wood G, Murrell A, Van Der Touw T, Smart N (2019) HIIT is not superior to MICT in altering blood lipids: a systematic review and meta-analysis. BMJ Open Sport Exerc Med 5:e000647. https://doi.org/10.1136/bmjsem-2019-000647

World Health Organization (2022) Physical activity factsheet. Available at https://www.who.int/news-room/fact-sheets/detail/physical-activity. Accessed in Jan 2024

Zampogna B, Papalia R, Papalia GF, Campi S, Vasta S, Vorini F, Fossati C, Torre G, Denaro V (2020) The role of physical activity as conservative treatment for hip and knee osteoarthritis in older people: a systematic review and meta-analysis. J Clin Med 9(4):1167