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ORIGINAL ARTICLE

Healthy lifestyle changes can improve quality of life: the Healthy Lifestyle Community Program (cohort 2; HLCP-2)

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Abstract

Aim Since unhealthy lifestyle behaviors, risk factors for noncommunicable diseases (NCDs), and diseases themselves can independently influence quality of life, lifestyle intervention programs addressing all of these may yield benefits for quality of life. This study aimed to examine the impact of the Healthy Lifestyle Community Program (HLCP-2) on quality of life in adults.

Subject and methods Data stem from a 24-month, non-randomized controlled lifestyle program which aimed to improve markers of NCD risk. Overall, 187 participants were assigned to either the intervention group (IG; $n = 112$) receiving a 10-week intensive lifestyle intervention on plant-based diet, physical activity, stress management, and community support, followed by a 22-month alumni phase, or a control group (CG; $n = 75$), without intervention. Quality of life was assessed by the EQ-5D-3L questionnaire at six measurement time points. Problems in five health dimensions ("mobility", "self-care", "usual activities", "pain/discomfort," and "anxiety/depression"), a visual analogue scale on self-rated health (EQ VAS), and the German EQ-5D index were addressed.

Results At baseline, 59.8% of the IG and 59.4% of the CG reported problems in ≥ 1 health dimension, with improvement in the IG at all time points. Compared to baseline, the EQ VAS increased significantly in the IG compared to CG at all time points. The mean EQ-5D index tended to improve in the IG, but changes did not differ significantly from changes in the CG.

Conclusion A lifestyle community program addressing lifestyle behaviors provides benefits for participants' self-rated health status, with the greatest effect after the intensive phase.

Trial registration German Clinical Trials Register DRKS (reference: DRKS00018775; 12.09.2019; retrospectively registered).

Keywords Community approach · EQ-5D-3L · Lifestyle intervention · Noncommunicable diseases · Quality of life

Introduction

Noncommunicable diseases (NCDs), such as cardiovascular diseases, cancer, and diabetes mellitus type 2, are responsible for approximately 70% of all deaths worldwide (Bigna and Noubiap 2019). They are associated with various modifiable lifestyle behaviors, such as unhealthy diets, physical inactivity, excessive alcohol consumption and tobacco use (World Health Organization 2021; Malone et al. 2021; Polak et al. 2015; Forouzanfar et al. 2016). Increasing risk factors for NCDs such as obesity, hypertension or high blood lipid levels as well as an unhealthy lifestyle, and the diseases themselves are associated with a reduced quality of life (for individuals) and high health-related costs (for society and the healthcare system) (Bloom et al. 2020; Jakovljevic and Milovanovic 2015; Saklayen 2018; Polak et al. 2015; Davies et al. 2012; van Wilder et al. 2020). Hence, promoting behaviors towards establishing long-term healthy lifestyle practices is important not only for preventing NCDs, avoiding possible comorbidities, and reducing healthcare costs, but also for improving quality of life (Beaglehole et al. 2011; Saklayen 2018; Kelishadi 2019; Wadden et al. 2012; Iwamoto et al. 2021; Phillips et al. 2020; Rahimi Foroushani et al. 2014). The promotion of a healthy lifestyle has

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considerable potential to improve quality of life for both the general population and patients at high risk of or with existing NCDs (Salas-Salvadó et al. 2019; Eaglehouse et al. 2016; Karimlou et al. 2019). Community-based lifestyle interventions can constitute a valuable tool for improving quality of life, in addition to reducing NCD-associated risk factors (Eaglehouse et al. 2016; Thankappan et al. 2018; Karamanakos et al. 2019; Ibrahim et al. 2016). In this way, health can be improved, and health-care costs and mortality risk can be decreased (Phyo et al. 2020; Kelishadi 2019; Zhang et al. 2021).

The multidimensional concept of quality of life is recognized as an important measure of a person's overall health and well-being, as it measures outcomes that are beyond biological function and morbidity (Phyo et al. 2020). The EuroQol EQ-5D questionnaire is the most commonly used survey for assessing quality of life in many countries, especially in Europe (Grobet et al. 2018; Rencz et al. 2016; Xie et al. 2014). This questionnaire can be used to measure health-related quality of life, independently of disease category and severity, in individuals with disease conditions in a clinical setting as well as healthy individuals in the general population. Thus, it is suitable for population surveys, economic evaluations, and clinical trials (König et al. 2009; Rabin and Charro 2001; Devlin and Brooks 2017; EuroQol Group 1990).

As previously reported, the Healthy Lifestyle Community Program (cohort 2; HLCP-2), an intensive lifestyle intervention with a community-based approach, was able to improve metabolic and anthropometric parameters (Anand et al. 2022; Koeder et al. 2021b, 2022). A secondary objective of the HCLP-2 was to test whether the intervention program would improve the quality of life of the participants from the general population in a community-based setting in Germany during the study period (i.e., from baseline to 10 weeks or from baseline to 24 months), both within the intervention group (IG) as well as compared to the control group (CG).

Methods

Study design

Data for this analysis derive from a non-randomized, controlled lifestyle intervention trial with a total duration of 24 months. The present analysis includes six measurement time points of the second cohort of the Healthy Lifestyle Community Program (HLCP-2; 2018–2020): baseline (t_0), 10 weeks (t_1), 6 months (t_2), 12 months (t_3), 18 months (t_4), and 24 months (t_5). In addition to quality of life, sociodemographic parameters and diagnosed diseases, health behavior, physical activity, psychological stress status, well-being, and health economic parameters (for the calculation of direct and indirect costs) were assessed by means of questionnaires. Semi-quantitative 3-day protocols were used to assess dietary intake, which were categorized by food groups. Blood parameters (e.g., cholesterol, triglycerides, and fasting glucose), anthropometric parameters (height, body weight, and waist circumference), and vital parameters (systolic and diastolic blood pressure and resting heart rate) were measured in the fasted state via in-person health check-ups. Due to the COVID-19 pandemic and contact restrictions, only questionnaire data were collected via post at the last measurement time point (t_5).

The intervention consisted of a community-based healthy lifestyle program. The CG received no intervention. As with all lifestyle interventions, blinding of participants or instructors to group allocation was not possible (as described previously; Koeder et al. 2021a). Due to the complex real-world public health approach and the inclusion of local (health) stakeholders in the planning stage of the intervention before the recruitment of the participants, it was not practical to randomize the participants individually or to conduct a cluster randomization (Renn 2018; Sanson-Fisher et al. 2014; see also Koeder et al. 2021a). The IG and CG study arms were conducted in parallel, but the CG study arm (start: October 2018) started and ended 6 months later than the IG arm (start: April 2018) for organizational reasons. The follow-up durations were equal in both groups. The study was registered in the German Clinical Trials Register (DRKS; reference: DRKS00018775; www.drks.de).

Participants

IG and CG participants were recruited from the general population in northwestern Germany, separated into an intervention municipality and a control municipality. Participants had to be at least 18 years old and needed to be physically and mentally able to take part in the study. Local stakeholders were involved in the recruitment of participants for the IG by offering a cooperative health market in the intervention municipality. Participants in the CG were mainly recruited at a local event. Distributing flyers and posters and publishing newspaper articles were also used to recruit participants in both municipalities. A total of 112 participants were allocated to the IG and 75 participants to the CG. All participants gave their written informed consent prior to inclusion in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the ethics committee of the Medical Association of Westphalia-Lippe and of the University of Münster (Münster, Germany; reference: 2018–171-f-S; approved 4 April 2018).

Intervention

The HLCP-2 consisted of a 10-week intensive phase followed by an approximately 22-month less intensive alumni phase. The intensive phase consisted of 14 consecutive seminars twice a week with a duration of 2 h each and eight additional workshop sessions in smaller groups (e.g., cooking classes, shopping tours, sports, stress regulation, and relaxation courses). Seminar topics included a healthy plant-based diet, physical activity, stress management, and community support. Dietary recommendations encouraged a healthy, plant-based diet, high in vegetables and fruits, whole grains, legumes, nuts, seeds, and healthy oils, and low in meat, high-fat diary, highly processed foods, and salt. An overview of the lifestyle recommendations have been published elsewhere (Köder 2022). Two one-on-one lifestyle coaching sessions were offered to the IG at baseline (t_0) and after 10 weeks (t_1). In addition, the participants received a healthy lifestyle handbook, a recipe booklet, and a one-pager with an overview of the key lifestyle recommendations. The less intensive alumni phase consisted of monthly seminars and regular email newsletters in which contents of the intensive phase were refreshed and group support was strengthened.

EQ-5D-3L

Health-related quality of life was assessed in both groups using the German version of the European Quality of Life–Five Dimensions questionnaire (EQ-5D-3L), which was introduced by the EuroQol Group in 1990 (EuroQol Group 1990). The EQ-5D-3L is a widely used generic self-assessment measurement instrument of current health, which has been validated for both describing and assessing quality of life in the context of interventions or treatments (Brooks 1996).

The descriptive system of the questionnaire comprises five dimensions: "mobility," "self-care," "usual activities," "pain/discomfort," and "anxiety/depression". For each dimension, the EQ-5D-3L-version categorizes responses on an ordinal scale with three levels, i.e., "(1) no problems", "(2) some problems", and "(3) extreme problems", resulting in individual EQ-5D-3L health profiles coded by five-digit numbers, differentiating 243 different kinds of health states. For example, "21212" indicates some problems (2) in mobility, usual activities, and anxiety/depression but no problems (1) in self-care or pain/discomfort, while "11111" means an optimal health status with no problems (1) in any of the five dimensions (EuroQol Group 2018). The questionnaire also contains a visual analogue scale, the EQ VAS, on which the participants report their self-rated health based on a 20-cm-long vertical scale, ranging from 0 ("worst imaginable health state") to 100 ("best imaginable health state") (EuroQol Group 1990). Using a value set which is based on local people's health preferences among a country's general population, the five-digit health profile can be converted into a single summary score, the EQ-5D index (EuroQol Group 2018). The VAS-based value set used in our intervention study was obtained from a random sample of the German general population (n = 339) and contains the EQ-5D index ranging from 0.021 (worst health status) to 1.000 (best health status) (Claes et al. 1999; EuroQol Group 2018).

Study hypotheses

The primary outcome parameter of the HLCP-2 trial was body weight, and the primary hypotheses were that the participants of the IG would reduce weight significantly during the study period compared to baseline and significantly more than participants of the CG (Koeder et al. 2021b). Quality of life was a secondary outcome parameter, and we hypothesized that the intervention would significantly increase health-related quality of life within the IG over time compared to baseline and that this increase would be significantly larger than in the CG.

Statistical analysis

To determine an adequate number of participants, a sample size calculation was performed based on changes in body weight, the primary outcome parameter of the HLCP-2 trial (as described previously; Koeder et al. 2021a), and eligible participants were included in the present secondary analysis accordingly. All data were analyzed according to a predefined analysis plan, performed on all available cases. Quantitative data are reported as means ± standard deviation (SD), and categorical variables are expressed as absolute numbers and percentages. The Shapiro–Wilk test was used to assess the data for normality, with $p < 0.05$ describing a non-normal distribution.

Between-group differences were analyzed using the independent t-test for normally distributed and the Mann–Whitney U test for non-normally distributed continuous variables. Fisher's exact test was used for between-group comparisons of categorical variables. To evaluate within-group changes, the paired t-test was used for normally distributed and the Wilcoxon signed-rank test for non-normally distributed variables. All tests were two-sided.

Since there was no randomization, multiple linear regression models were created to compare the groups regarding the changes in the EQ VAS and EQ-5D index (from baseline to the other five measurement points). Potential confounders were added as covariates to the multiple regression models using a forward selection approach. Regression models that were statistically significant (general linear F-test: $p \leq 0.05$) with the highest corrected R^2 and lowest number of covariates were selected as final models. In all regression models,

residuals were checked for normality. For all analysis, results were considered significant at $p \leq 0.05$ and are to be understood as exploratory (Gaus 2015), because all data presented are secondary outcome parameters. Statistical analysis was performed using SPSS version 27 for Windows (IBM Corporation, Armonk, NY, USA).

Results

Baseline characteristics

Data were available for a total of 186 participants (IG: $n = 111$; CG: $n = 75$), and these participants were included in the data analysis (Fig. 1).

Baseline characteristics of both groups are shown in Table 1. The majority in both groups were female (IG: 68.5%; CG: 60%), were middle-aged (mean age; IG: 59.3 years [± 8.9]; CG: 54.0 years [± 10.3]), and reported at least one disease diagnosed by a physician (IG: 82.2%; CG: 75.4%). At baseline, the IG had a higher mean age ($p < 0.001$) and a higher educational level ($p = 0.001$) than the CG. No significant between-group differences were observed in terms of other baseline characteristics. Additionally, the presence of specific diseases, such as hypertension, heart and peripheral artery disease, diabetes mellitus, thyroid disease, gastrointestinal diseases, allergies, retinopathy, peripheral neuropathy, diabetic foot, depression, cancer, rheumatoid arthritis, chronic pain, and skeletal and lung disease, as well as "other diseases" and "no diagnosed disease", were similar between groups, except for a diagnosed dyslipidemia (IG: 22.4%; CG: 10.1%; $p = 0.043$).

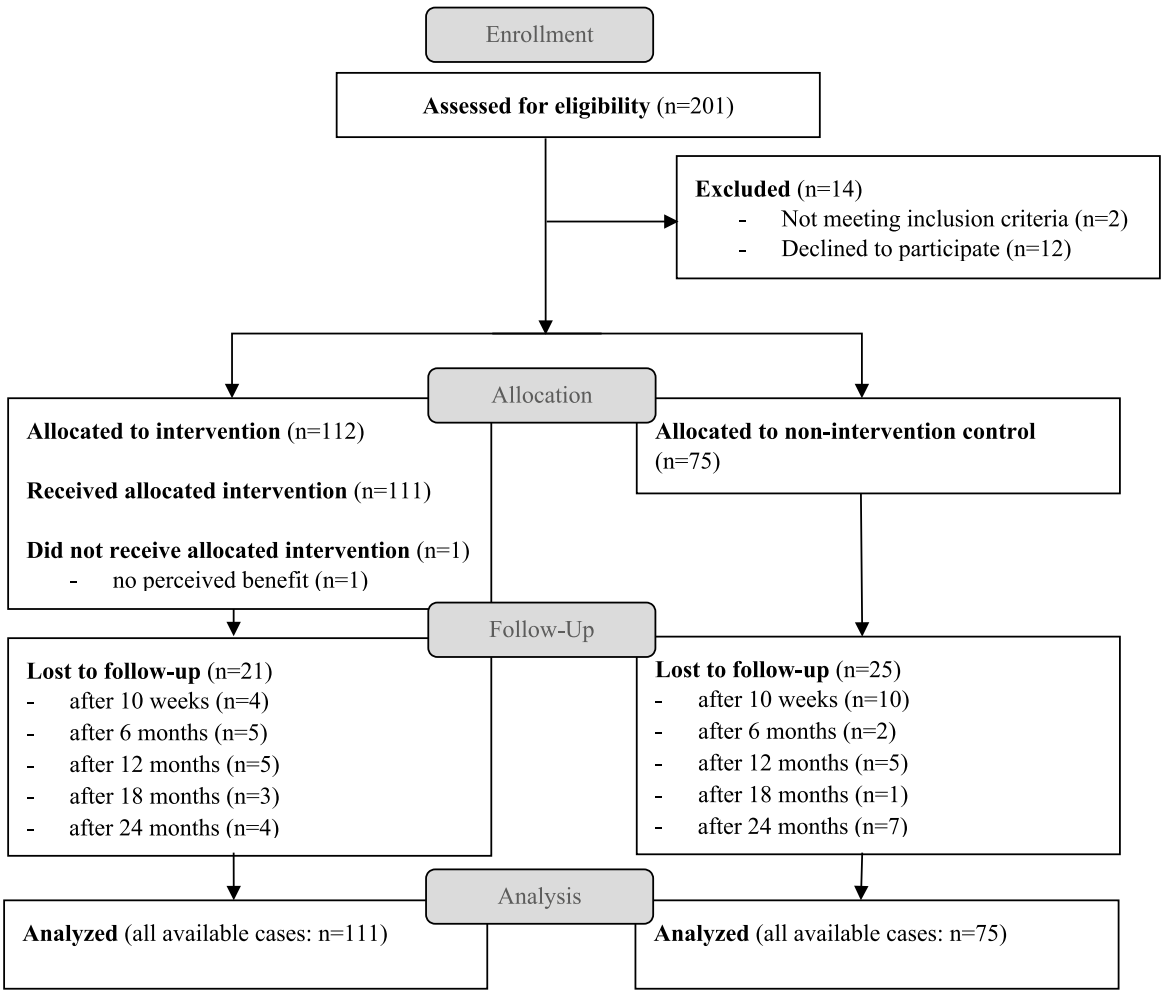


Fig. 1 CONSORT participants' flow diagram; participants categorized as "lost to follow-up" did not show up to health checks or withdrew from the study

Table 1 Baseline characteristics by study groups

Variable	Intervention group	Control group	*p*-value
Sociodemographic data	*n* = 111	*n* = 75	
Female sex: *n* (%)	76 (68.5)	45 (60.0)	0.273[a]
Age, years: mean (± SD)	59.3 ± 8.9	54.0 ± 10.3	**< 0.001**[b]
Marital status, *n* (%)	*n* = 108	*n* = 69	0.539[a]
Married	87 (80.6)	60 (87.0)	
Partner, unmarried	6 (5.6)	3 (4.3)	
Single (not widowed)	11 (10.2)	3 (4.3)	
Single (widowed)	4 (3.7)	3 (4.3)	
Education level, *n* (%)	*n* = 108	*n* = 69	**0.001**[a]
Lower secondary school	20 (18.5)	26 (37.7)	
Secondary school	45 (41.7)	21 (30.4)	
University entrance qualification	22 (20.4)	19 (27.5)	
University degree	21 (19.4)	3 (4.3)	
Anthropometric data: mean ± SD	*n* = 110	*n* = 75	
Body weight, kg: mean ± SD	82.0 ± 18.7	86.8 ± 19.6	0.064[c]
BMI, kg/m^2: mean ± SD	27.8 ± 5.3	28.6 ± 5.8	0.424[c]
Waist circumference, cm: mean ± SD	99.1 ± 15.1	99.0 ± 16.9	0.942[b]
Diagnosed disease and medication use	*n* = 107	*n* = 69	
Diagnosed with a disease, *n* (%)	88 (82.2)	52 (75.4)	0.339[a]
Regular medication use, *n* (%)	77 (72.0)	40 (58.0)	0.072[a]
Vital signs: mean ± SD	*n* = 110	*n* = 75	
Systolic BP, mm Hg	135.0 ± 15.6	131.3 ± 16.6	0.125[b]
Diastolic BP, mm Hg	81.7 ± 8.6	79.4 ± 9.8	0.140[c]
Pulse	68.7 ± 10.5	69.1 ± 10.1	0.757[b]
Blood parameters: mean ± SD	*n* = 109	*n* = 75	
TC, mg/dL	205.2 ± 37.5	205.9 ± 41.6	0.911[b]
HDL-C, mg/dL	64.3 ± 18.4	61.0 ± 18.0	0.200[c]
LDL-C, mg/dL	131.9 ± 34.7	136.9 ± 40.8	0.373[b]
TG, mg/dL	106.9 ± 53.8	119.8 ± 79.8	0.387[c]
Fasting glucose, mg/dL	100.0 ± 16.1	106.9 ± 30.0	0.472[c]
HbA1c, %	5.5 ± 0.5	5.6 ± 0.7	0.735[c]
Smoking status: *n* (%)	*n* = 109	*n* = 70	0.192[a]
Current/occasional	14 (12.8)	16 (22.9)	
Ex	39 (35.8)	20 (28.6)	
Never	56 (51.4)	34 (48.6)	

SD standard deviation, *BMI* body mass index, *BP* blood pressure, *TC* total cholesterol, *LDL-C* LDL cholesterol, *HDL-C* HDL cholesterol, *TG* triglycerides

[a]Fisher's exact test (two-sided); [b] independent *t*-test (two-sided); [c] Mann–Whitney *U* test (two-sided). Values in bold indicate significance

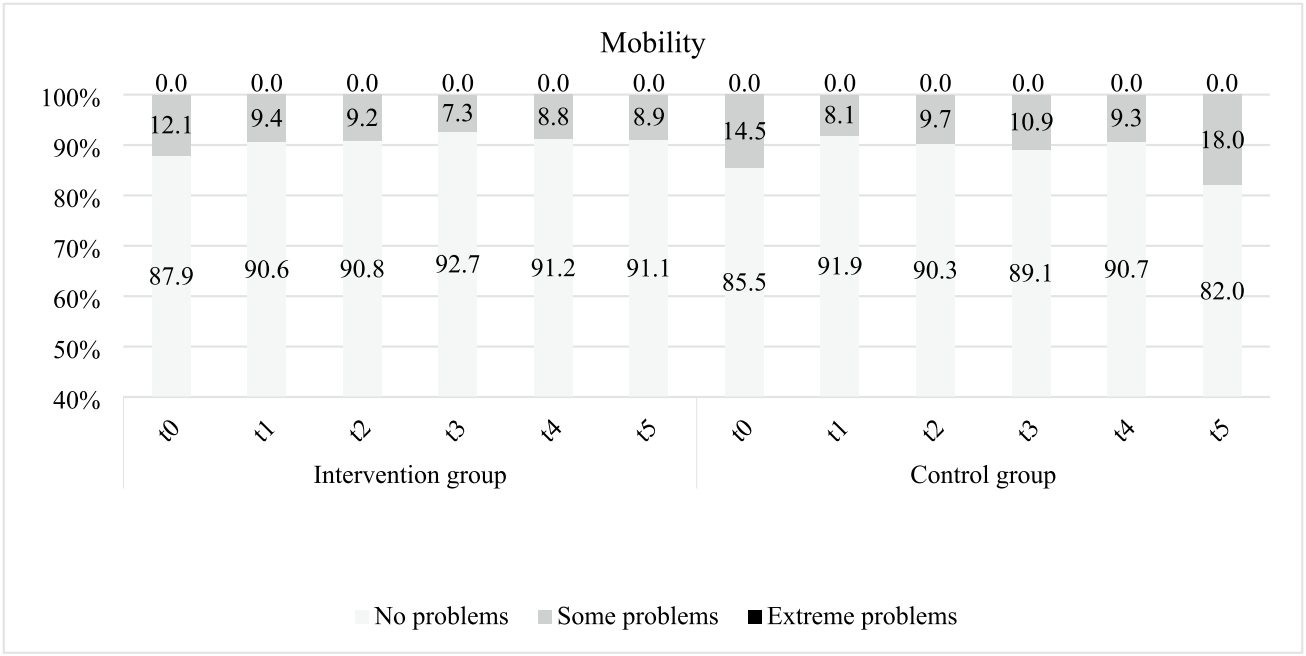
Descriptive health profile

At baseline (t_0), 59.8% of IG participants reported problems in at least one of the EQ-5D-3L dimensions. This value decreased at all time points compared to baseline (t_1: 43.4%, t_2: 44.9%, t_3: 43.8%, t_4: 49.5%, and t_5: 43.3%), with the greatest improvements after 10 weeks (t_1) and 24 months (t_5). In comparison, 59.4% of CG reported problems in ≥ 1 dimension of the EQ-5D-3L at baseline, with an improvement at 10 weeks (t_1: 50.8%), 6 months (t_2: 46.8%), 12 months (t_3: 58.2%), and 18 months (t_4: 53.7%), and a deterioration at 24 months (t_5: 60.0%), compared to baseline.

Overall, at baseline, the problems most frequently observed were in terms of pain/discomfort (IG: 49.5%; CG: 52.2%), followed by anxiety/depression (IG: 28.0%; CG: 34.8%), mobility (IG: 12.1%; CG: 14.5%), and finally in the dimension usual activities (IG: 8.4%; CG: 8.7%). In self-care, just one participant of the IG reported problems (0.9%), and no problems were reported in the CG at baseline (Fig. 2). Additional data on EQ-5D-3L dimensions over the course of the study are given in Additional file 1.

EQ VAS and EQ-5D index

Table 2 describes the EQ VAS and the EQ-5D index for the IG and CG during the study course (t_0-t_5) and shows the change in this parameters after 10 weeks (t_1), 6 months (t_2), 12 months (t_3), 18 months (t_4) and 24 months (t_5) compared to baseline. At baseline, the EQ VAS ($p=0.066$) and EQ-5D index ($p=0.617$) were comparable between the two study groups, with EQ VAS (IG:



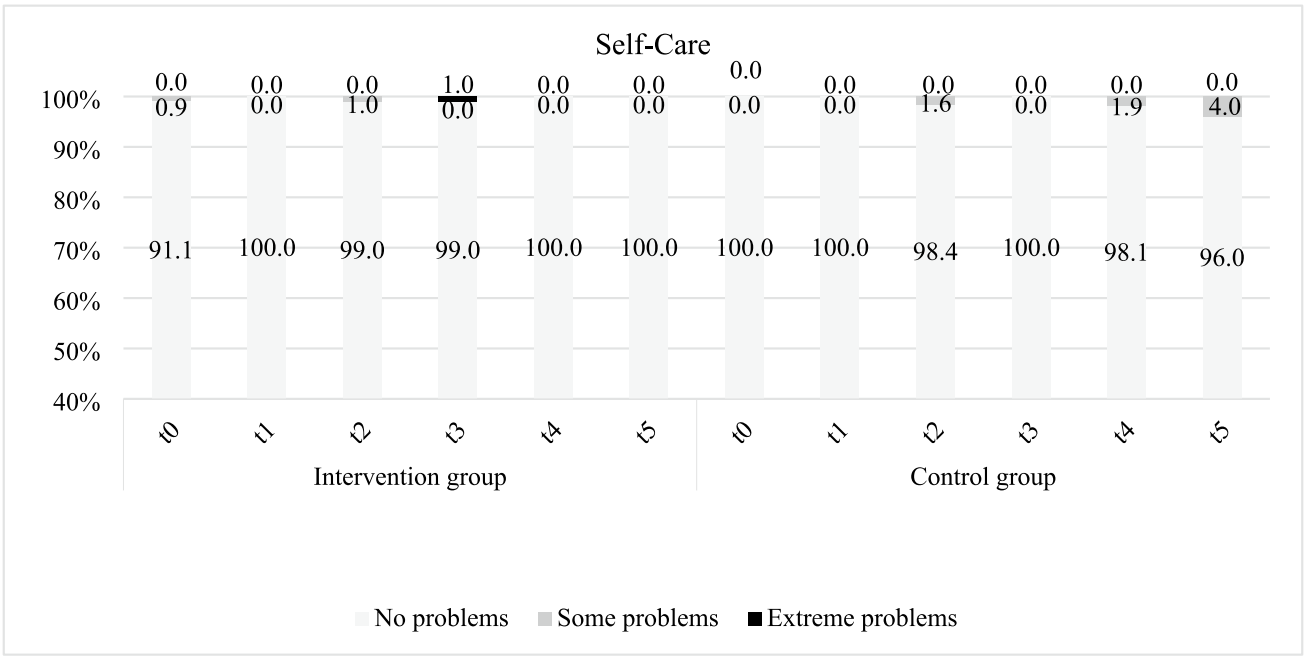
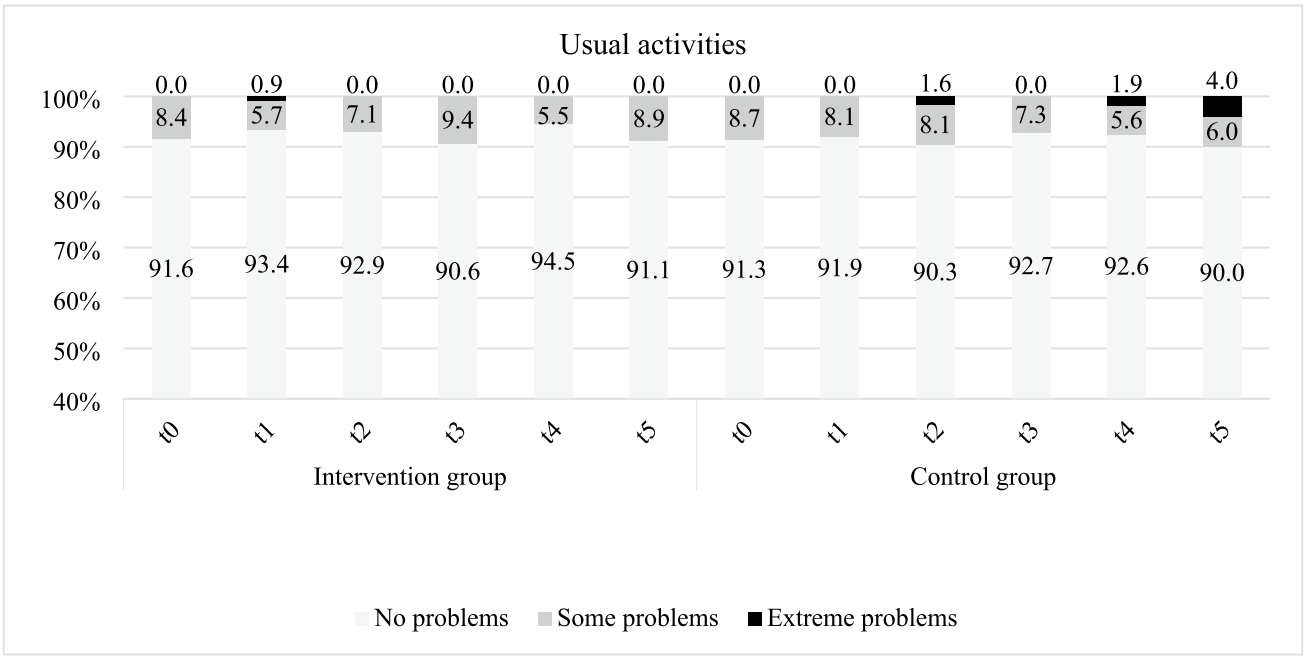
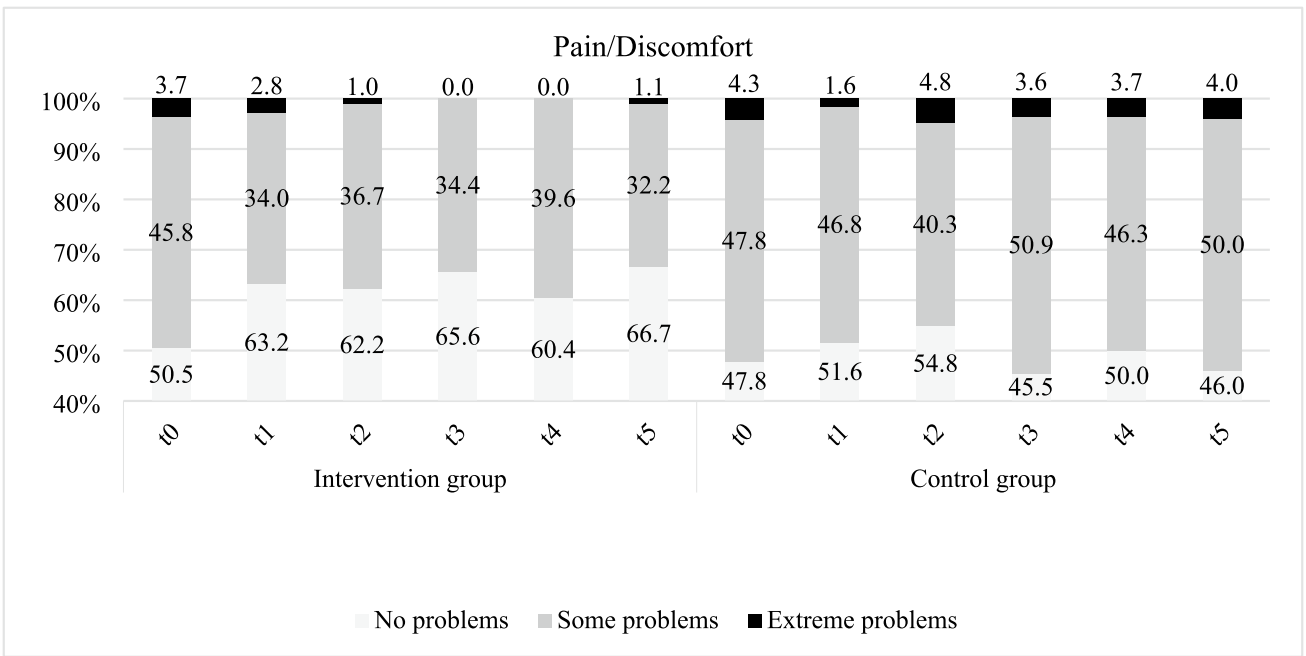


Fig. 2 EQ-5D-3L dimensions at baseline (t_0), after 10 weeks (t_1), and after 6 (t_2), 12 (t_3), 18 (t_4), and 24 (t_5) months for the intervention and control groups





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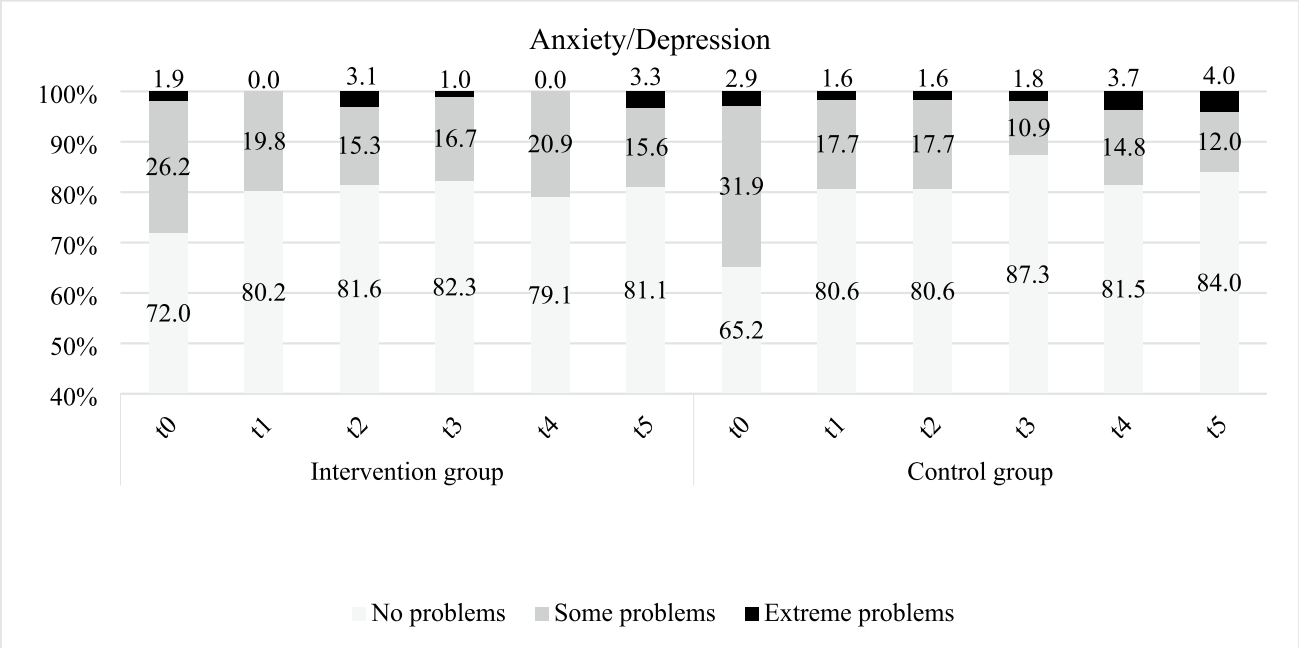

Fig. 2 (continued)

73.93 ± 14.87; CG: 76.81 ± 17.94) being higher in the CG than in the IG. The EQ-5D index (IG: 0.87 ± 0.17; CG: 0.85 ± 0.18) showed slightly higher values in the IG than in the CG. The change in EQ VAS compared to baseline differed significantly between the study groups at all time points compared to baseline ($t_0 - t_1$: $p < 0.001$; $t_0 - t_2$: $p = 0.047$; $t_0 - t_3$: $p = 0.024$; $t_0 - t_4$: $p = 0.002$; $t_0 - t_5$: $p = 0.004$). Within the IG, the EQ VAS also improved significantly at all measurement time points ($t_0 - t_1$: $p < 0.001$; $t_0 - t_2$: $p < 0.001$; $t_0 - t_3$: $p < 0.001$; $t_0 - t_4$: $p < 0.001$; $t_0 - t_5$: $p < 0.001$). The between-group differences in the EQ-5D index change were not significant for any measurement time point. The EQ-5D index tend to increase within the IG at all measurement time points compared to baseline, with significant improvements identified after 10 weeks ($p = 0.012$), 6 months ($p = 0.031$), and 12 months ($p = 0.013$). In the CG, no significant changes were observed for either parameter at any time point.

Linear regression modeling

Results from multiple linear regression (MLR) analysis, with changes in the EQ VAS (Table 3) and the EQ-5D index (Table 4) as dependent variables, are presented in the following.

The EQ VAS change (Table 3) differed significantly between the IG and CG after 10 weeks ($p < 0.001$), 6 months ($p = 0.032$), 12 months ($p = 0.004$), 18 months ($p = 0.001$), and 24 months ($p = 0.004$). Higher EQ VAS baseline values were associated with a lower EQ VAS improvement in all models. The models also indicate that long-term improvement in EQ VAS was lower in participants with thyroid diseases ($t_0 - t_2$: $p = 0.002$, $t_0 - t_3$: $p < 0.001$, $t_0 - t_4$: $p = 0.041$, and $t_0 - t_5$: $p = 0.001$) but higher with diagnosed diabetes mellitus ($t_0 - t_4$: $p < 0.048$).

The MLR models for the change in EQ-5D index (Table 4) indicate no significant differences between the two groups at any measurement time point ($t_0 - t_1$: $p = 0.937$; $t_0 - t_2$: $p = 0.531$; $t_0 - t_3$: $p = 0.398$; $t_0 - t_4$: $p = 0.369$; and $t_0 - t_5$: $p = 0.144$). However, the models suggest that pulse at baseline ($t_0 - t_2$: $p = 0.001$), regular medication use at baseline ($t_0 - t_2$: $p = 0.004$), weight at baseline ($t_0 - t_3$: $p = 0.011$), and various diagnosed diseases such as allergies ($t_0 - t_1$: $p = 0.001$; $t_0 - t_3$: $p < 0.001$; $t_0 - t_4$: $p < 0.001$; $t_0 - t_5$: $p = 0.001$), retinopathy ($t_0 - t_3$: $p = 0.005$), and gastrointestinal diseases ($t_0 - t_5$: $p < 0.001$) can influence how much the EQ-5D index changed. Furthermore, the models indicate that a small EQ-5D index at baseline induced larger changes after all time points compared to baseline ($p < 0.001$). Other parameters including age, sex, education level, and smoking status, as well as blood, anthropometric, and blood pressure parameters, were not identified to have a significant influence on the EQ VAS or the EQ-5D index.

Table 2 EQ VAS and EQ-5D index during the study period ($t_0 - t_5$) compared to baseline for the intervention and control group; all values are mean ± SD

		t_0^1	t_1^1	*p*-value #.[2]	t_2^1	*p*-value #.[2]	t_3^1	*p*-value #.[2]	t_4^1	*p*-value #.[2]	t_5^1	*p*-value #.[2]
EQ VAS	IG	73.93 ± 14.87	80.42*** ± 12.36	**< 0.001**	79.67*** ± 12.69	**0.047**	79.25*** ± 13.77	**0.024**	79.16*** ± 13.18	**0.002**	79.66*** ± 14.16	**0.004**
	CG	76.81 ± 17.94	75.13 ± 17.84		78.13 ± 17.16		76.35 ± 18.80		75.20 ± 16.02		77.50 ± 14.92	
EQ-5D index	IG	0.87 ± 0.17	0.90* ± 0.15	0.754	0.90* ± 0.15	0.642	0.91* ± 0.13	0.707	0.91 ± 0.11	0.771	0.90 ± 0.15	0.151
	CG	0.85 ± 0.18	0.90 ± 0.15		0.89 ± 0.18		0.89 ± 0.15		0.88 ± 0.18		0.87 ± 0.19	

Wilcoxon test for within-group differences, with *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ for within-group comparison to baseline; Mann–Whitney *U* test for between-group differences; # *p*-value for between-group comparison (reference: t_0). Values in bold indicate significance. *IG* intervention group; *CG* control group; *SD* standard derivation

[1] IG: t_0: $n = 107$, t_1: $n = 106$, t_2: $n = 98$, t_3: $n = 96$, t_4: $n = 91$, t_5: $n = 90$; CG: t_0: $n = 69$, t_1: $n = 62$, t_2: $n = 62$, t_3: $n = 55$, t_4: $n = 54$, $t_5 - t_0$: $n = 50$

[2] IG: $t_1 - t_0$: $n = 104$, $t_2 - t_0$: $n = 96$, $t_3 - t_0$: $n = 94$, $t_4 - t_0$: $n = 90$, $t_5 - t_0$: $n = 88$; CG: $t_1 - t_0$: $n = 61$, $t_2 - t_0$: $n = 61$, $t_3 - t_0$: $n = 54$, $t_4 - t_0$: $n = 53$, $t_5 - t_0$: $n = 49$

Table 3 Multiple linear regression models for EQ VAS change after 10 weeks and 6, 12, 18, and 24 months

	ß	SE	*p*-value
10 weeks[1]			
Constant ($ß_0$)	27.966	3.715	**< 0.001**
Group (ref. intervention)	−6.896	1.545	**< 0.001**
EQ VAS at baseline	−0.295	0.048	**< 0.001**
6 months[2]			
Constant ($ß_0$)	31.563	4.173	**< 0.001**
Group (ref. intervention)	−3.517	1.621	**0.032**
EQ VAS at baseline	−0.346	0.053	**< 0.001**
Diagnosed thyroid diseases	−8.511	2.736	**0.002**
12 months[3]			
Constant ($ß_0$)	33.215	4.645	**< 0.001**
Group (ref. intervention)	−5.542	1.869	**0.004**
EQ VAS at baseline	−0.361	0.059	**< 0.001**
Diagnosed thyroid diseases	−14.384	3.131	**< 0.001**
18 months[4]			
Constant ($ß_0$)	30.132	5.021	**< 0.001**
Group (ref. intervention)	−6.121	1.819	**0.001**
EQ VAS at baseline	−0.342	0.063	**< 0.001**
Diabetes mellitus	8.603	4.311	**0.048**
Diagnosed thyroid diseases	−6.382	3.093	**0.041**
24 months[5]			
Constant ($ß_0$)	33.141	5.273	**< 0.001**
Group (ref. intervention)	−5.724	1.980	**0.004**
EQ VAS at baseline	−0.361	0.068	**< 0.001**
Diagnosed thyroid diseases	−11.122	3.335	**0.001**

Dependent variable: change in EQ VAS (compared to baseline); all residuals are normally distributed. Values in bold indicate significance

[1] corr. $R^2 = 0.263$. FS, general linear *F*-test: $p < 0.001$. $n = 165$

[2] corr. $R^2 = 0.239$. FS, general linear *F*-test: $p < 0.001$. $n = 157$

[3] corr. $R^2 = 0.277$. FS, general linear *F*-test: $p < 0.001$. $n = 148$

[4] corr. $R^2 = 0.282$. FS, general linear *F*-test: $p < 0.001$. $n = 143$

[5] corr. $R^2 = 0.249$. FS, general linear *F*-test: $p < 0.001$. $n = 137$

SE standard error; *ref.* reference group

Discussion

The results of the present analysis show that the HLCP-2 intervention led to a significant improvement in the EQ VAS at all time points compared to baseline, with the greatest improvement after the 10-week intensive phase. Conversely, the EQ-5D index did not improve significantly between the groups ($p > 0.05$). The reported problems in the EQ-5D-3L dimensions decreased at all time points within both groups, except within the CG at t_5 compared to baseline. The improvement in self-perceived quality of life in the IG may be attributed to changes in lifestyle factors, such as a healthy plant-based diet, physical activity and social support

Table 4 Multiple linear regression models for EQ-5D index change after 10 weeks and 6, 12, 18, and 24 months

	ß	SE	*p*-value
10 weeks[1]			
Constant ($ß_0$)	0.619	0.074	**< 0.001**
Group (ref. intervention)	−0.001	0.018	0.937
EQ-5D index at baseline	−0.451	0.053	**< 0.001**
Diagnosed allergy	−0.211	0.064	**0.001**
Pulse at baseline	−0.003	0.001	**0.001**
6 months[2]			
Constant ($ß_0$)	0.413	0.062	**< 0.001**
Group (ref. intervention)	−0.013	0.021	0.531
EQ-5D index at baseline	−0.393	9.964	**< 0.001**
Regular medication use at baseline	−0.062	0.021	**0.004**
12 months[3]			
Constant ($ß_0$)	0.522	0.061	**< 0.001**
Group (ref. intervention)	−0.14	0.017	0.398
EQ-5D index at baseline	−0.452	0.053	**< 0.001**
Diagnosed retinopathy	0.128	0.045	**0.005**
Diagnosed allergy	−0.200	0.057	**< 0.001**
Weight at baseline	−0.001	0.000	**0.011**
18 months[4]			
Constant ($ß_0$)	0.485	0.060	**< 0.001**
Group (ref. intervention)	−0.018	0.020	0.369
EQ-5D index at baseline	−0.512	0.066	**< 0.001**
Diagnosed allergy	−0.235	0.055	**< 0.001**
24 months[5]			
Constant ($ß_0$)	0.367	0.073	**< 0.001**
Group (ref. intervention)	−0.036	0.023	0.114
EQ-5D index at baseline	−0.374	0.080	**< 0.001**
Diagnosed allergy	−0.247	0.074	**0.001**
Diagnosed gastrointestinal diseases	−0.186	0.055	**< 0.001**

Dependent variable: change in EQ-5D index (compared to baseline); all residuals are normally distributed

[1] corr. $R^2 = 0.346$. FS, general linear *F*-test: $p < 0.001$. $n = 165$

[2] corr. $R^2 = 0.196$. FS, general linear *F*-test: $p < 0.001$. $n = 157$

[3] corr. $R^2 = 0.400$. FS, general linear *F*-test: $p < 0.001$. $n = 148$

[4] corr. $R^2 = 0.317$. FS, general linear *F*-test: $p < 0.001$. $n = 143$

[5] corr. $R^2 = 0.186$. FS, general linear *F*-test: $p < 0.001$. $n = 137$

SE standard error; *ref.* reference group

(Da Oliveira et al. 2019; Bonaccio et al. 2013; Onu et al. 2022), and improvements in NCD risk factors including body weight, waist circumference, and blood parameters (e.g., cholesterol) (Eaglehouse et al. 2016; Thankappan et al. 2018; Karamanakos et al. 2019; Ibrahim et al. 2016), which have been published previously (Koeder et al. 2021b).

At baseline, more than half of the participants in both groups (IG: 59.8%; CG: 59.4%) reported problems in ≥ 1 dimension (EQ-5D-3L), which indicated a lower health status compared to a representative sample of non-institutionalized adults from Germany, among whom 36% reported problems in ≥ 1 dimension (König et al. 2005). It should be noted that the mean age of 48.1 ± 16 years of this representative sample was substantially lower than the mean age in the IG (59.3 ± 8.9 years) and CG (54.0 ± 10.3 years) of the present study, and that quality of life decreases with increasing age in most dimensions (König et al. 2005). The health status improved in both groups during the course of the study, except for the last measurement time point of the CG, with larger increases in the IG than the CG. Consistent with the results by König et al. (2005), who assessed the quality of life in the adult general population in Germany ($n = 3.552$), and results by Anillo Arrieta et al. (2021), who evaluated the quality of life of individuals at high risk for type 2 diabetes in Latin America ($n = 1.135$), problems with pain/discomfort were reported most frequently and problems with self-care less frequently in both groups at all measurement time points. However, while on average only 4% of the representative German sample reported problems with anxiety/depression, the participants reported notably more problems in this dimension at baseline (at least some problems with anxiety/depression; IG: 28.0%; CG: 34.8%) (König et al. 2005). The presence of NCDs can have a considerable negative impact on patients' quality of life (Xu et al. 2017), which could be the reason for the adverse values at baseline and therefore greater potential for improvements achieved through the lifestyle intervention.

Compared to the national average of 77.4 ± 19 in Germany (König et al. 2005), in the IG of the present study, the baseline mean EQ VAS was slightly lower (t_0: 73.93 ± 14.87). After the intensive phase (t_1: 80.42 ± 12.36), it was higher than the national average in Germany and remained higher during the course of the study, which indicates that the community-based HLCP-2 intervention can increase long-term quality of life. In the CG, the EQ VAS exceeded the German national average (König et al. 2005) only after 6 months (t_2: 78.13 ± 17.16).

The changes in the EQ VAS observed in the present study are comparable to the results observed at 6 and 12 months in a study by Eaglehouse et al. (USA) with a diabetes prevention program for adults with prediabetes and/or metabolic syndrome. Their community-based intervention program focused on dietary and physical activity behaviors and weight loss and was able to significantly increase the EQ VAS, whereas the EQ-5D index mean changes in the unadjusted results were minimal (Eaglehouse et al. 2016). The participants in that study were high-risk patients or already suffered from NCDs and showed a comparatively low EQ VAS value at baseline (EQ VAS at t_0: 71.5 ± 16.6) (Eaglehouse et al. 2016).

Janssen et al. (2019) compiled EQ-5D-3L population norms for 20 different countries to facilitate comparisons between patients with health conditions and the general population.

This compilation includes additional data regarding the EQ-5D index. The average EQ-5D index, which is based on the German VAS value set, is higher than the results observed in the present study for both groups and all time points (Janssen et al. 2019). The comparatively low EQ-5D baseline values in both groups of the present study may be attributed to the setting of the study, as the quality of life in rural municipalities is frequently lower than in urban communities (Kaczmarek et al. 2017; Weeks et al. 2006; Zhang et al. 2022).

The EQ-5D-3L questionnaire might not be as precise if many participants do not report health problems in any dimension and may additionally be less sensitive in distinguishing between high scores in the healthy utility range (Eaglehouse et al. 2016; Schulz et al. 2014; Kopec 2003). Hence, the fact that few extreme problems and frequently no problems were reported at baseline in our study may have reduced our ability to identify notable improvements in the EQ-5D index. This could be the reason that no statistically significant EQ-5D index differences were found between the groups.

The COVID-19 pandemic may have negatively influenced the quality of life at the final measurement time points (IG: t_5; CG: t_4 and t_5) (König et al. 2023). However, the EQ VAS and EQ-5D index in the IG were higher after 24 months than at baseline, while no significant changes for either parameter were observed in the CG throughout the course of the study. This emphasizes the high potential of the HLCP-2, since the quality of life, despite the COVID-19 pandemic and associated contact restrictions, remained higher than baseline values.

Strengths and limitations

A strength of the present study is the use of a non-intervention control group and the use of a validated generic instrument to assess health-related quality of life. One limitation is that the control group started with a delay of 6 months compared to the intervention group, although the follow-up durations were the same. In general, the intervention and control groups had similar baseline characteristics, except for age and education level, and in the statistical analysis, various potential confounders were adjusted for. All participants were recruited in two small municipalities in Germany, which could mean that the results are not applicable to individuals in larger cities. Furthermore, the German value set for the EQ-5D-3L questionnaire was used for data analysis. This might limit the generalizability of our results to patients in other countries and healthcare systems. However, Konerding et al. showed strong evidence for the generalizability of EQ-5D-3L-based results when comparing value sets of Germany, England, Finland, Greece, and the Netherlands, assuming that the countries' results are comparable (Konerding et al. 2014).

Conclusions

In summary, the results indicate that the HLCP-2 intervention can effectively improve some aspects of quality of life, especially after the 10-week intensive phase. Thus, it appears that the HLCP-2 intervention would have a positive effect at both the individual and societal levels. The results could be attributed to lifestyle changes and/or a reduction of NCD risk factors, and the results are in accord with findings from several previous studies that have documented an effect of lifestyle changes on quality of life. The results of the present study can sensitize health stakeholders to the potential of community-based lifestyle interventions for improving quality of life and lowering NCD risk.

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Data availability The data are available from the corresponding author (RMW) upon reasonable request.

Declarations

Consent to participate All participants were informed and gave their written consent before participating in the study.

Ethics approval All procedures performed in this study were approved by the Ethics Committee of the Medical Association of Westphalia-

Lippe and of the University of Münster (Münster, Germany; reference: 2018–171-f-S; approved 4 April 2018) and performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments or comparable standards. The study was registered by the German Clinical Trials Register DRKS (reference: DRKS00018775; 12.09.2019; retrospectively registered).

Conflict of interest The authors have no competing interests to declare.

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