

Muva physical activity intervention improves social functioning in people with a severe mental illness: A pragmatic stepped wedge cluster controlled trial

Lisanne Elisabeth Maria Koomen^{a,b,*}, Ilona Hendrika Theodora van de Meent^{a,c,1}, Jeroen Deenik^{a,d,e}, Edwin van Dellen^a, Hugo Gerard Schnack^{a,c}, Cornelis Hendrikus van Werkhoven^{a,c,f}, Wilma Elisabeth Swildens^{g,h}, Berno van Meijel^{h,i,j}, Wouter Staal^{k,l}, Frederike Jörg^m, Floortje Scheepers^a, Wiepke Cahn^{a,g}

^a UMC Utrecht, Heidelberglaan 100, 3584CX, Utrecht, the Netherlands

^b Lister, Furkaplateau 15, 3524 ZH, the Netherlands

^c Utrecht University, Heidelberglaan 8, 3584CS, Utrecht, the Netherlands

^d Maastricht University, Minderbroedersberg 4-6, 6211LK, Maastricht, the Netherlands

^e GGZ Centraal, Utrechtseweg 266, 3818EW, Amersfoort, the Netherlands

^f Julius Center for Health Sciences and Primary Care, the Netherlands

^g Altrecht Mental Health Institute, Lange Nieuwstraat 119, 3512PG, Utrecht, the Netherlands

^h Inholland University of Applied Sciences, De Boelelaan 1109, 1081HV, Amsterdam, the Netherlands

ⁱ Amsterdam UMC (VUmc), Amsterdam Public Health research institute, De Boelelaan 1105, 1081HV, Amsterdam, the Netherlands

^j Parnassia Psychiatric Institute, Kivistraat 43, 2552 DH, The Hague, the Netherlands

^k University Leiden, Rapenburg 70, 2311EZ, Leiden, the Netherlands

^l RadboudUMC, Nijmegen, Geert Grooteplein Zuid 10, 6525GA, Nijmegen, the Netherlands

^m University of Groningen, University Medical Center Groningen, Hanzeplein 1, 9713GZ, Groningen, the Netherlands

ARTICLE INFO

Keywords:

Physical activity
Severe mental illness
Stepped wedge trial
Healthy lifestyle
lifestyle psychiatry
Social functioning
eHealth
Supported housing

ABSTRACT

Severe mental illness (SMI) imposes a significant burden on individuals, resulting in long-lasting symptoms, lower social functioning and impaired physical health. Physical activity (PA) interventions can improve both mental and physical health and care workers can serve as healthy role models. Yet, individuals with SMI face barriers to PA participation. This study evaluated the effects of Muva, and assessed if mental health worker's (MHW) characteristics were associated with clients' change in social functioning. Muva, an intervention package primarily created to increase PA of people with SMI, places a special focus on MHWs as they might play a key role in overcoming barriers. Other PA barrier-decreasing elements of Muva were a serious game app, lifestyle education, and optimization of the medication regime.

Method: This study is a pragmatic stepped wedge cluster controlled trial. Controls received care as usual. Mixed-effects linear regressions were performed to assess changes in the primary outcome social functioning, and secondary outcomes quality of life, psychiatric symptoms, PA, body mass index, waist circumference, and blood pressure.

Results: 84 people with SMI were included in three intervention clusters, and 38 people with SMI in the control cluster. Compared to the control condition, there was significant clinical improvement of social functioning in interpersonal communication ($p < 0.01$) and independent competence ($p < 0.01$) in people receiving Muva.

* Corresponding author.

E-mail addresses: l.e.m.koomen-2@umcutrecht.nl (L.E. Maria Koomen), I.H.T.vandeMeent@umcutrecht.nl (I.H. Theodora van de Meent), j.deenik@ggzcentraal.nl (J. Deenik), E.vanDellen-2@umcutrecht.nl (E. van Dellen), H.Schnack@umcutrecht.nl (H.G. Schnack), c.h.vanwerkhoven@umcutrecht.nl (C. Hendrikus van Werkhoven), w.swildens@altrecht.nl (W.E. Swildens), Berno.vanMeijel@inholland.nl (B. van Meijel), w.staal@karakter.com (W. Staal), f.jorg@umcg.nl (F. Jörg), f.scheepers@umcutrecht.nl (F. Scheepers), w.cahn@umcutrecht.nl (W. Cahn).

¹ These authors have contributed equally to this work and share first authorship.

<https://doi.org/10.1016/j.mhpa.2024.100601>

Received 15 November 2023; Received in revised form 1 May 2024; Accepted 1 May 2024

Available online 4 May 2024

1755-2966/© 2024 UMC Utrecht. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

These outcomes were not associated with MHW's characteristics. There were no changes in the other outcome measures.

Conclusions: Muva improved social functioning in people with SMI compared to care as usual.

1. Introduction

Severe mental illness (SMI), a psychiatric disorder with enduring symptoms resulting in significant impairment in psychosocial functioning lasting for at least two years, imposes a significant burden on individuals, affecting both their mental and physical health (Delespaul, 2013). Despite treatment, people with SMI often face long-lasting symptoms resulting in serious challenges in social functioning and lower quality of life (Hoof et al., 2014; Patel et al., 2018; Salzer et al., 2018). Physical activity (PA) interventions have found to be promising in improving social functioning, i.e. an individual's ability to effectively manage social interactions, relationships, and societal roles, and quality of life. This is because PA interventions can decrease psychiatric symptoms, increase self-esteem, reduce social isolation by engaging in sport activities with others and can give a sense of belonging and inclusion (Czosnek et al., 2019; Eather et al., 2023; Firth et al., 2020; Franco et al., 2015; Mason & Holt, 2012; Purgato et al., 2023; Rodriguez-Ayllon et al., 2023). PA is not only advantageous for mental health in people with SMI, but also for physical health (Firth et al., 2019; Stubbs et al., 2018). This is important since they face a 1.4–2 times higher risk to develop cardiometabolic diseases and have a 15–20 year lower life expectancy compared to the general population (Plana-Ripoll et al., 2019, 2020; Walker et al., 2015).

However, despite the potential benefits of PA for both physical and mental health, PA is often not integrated within routine psychiatric treatment and rehabilitation care (Deenik et al., 2019). Barriers at patient and organizational level impede implementation of PA in standard practice. At patient level there are disease specific barriers including symptoms, a vulnerable physical condition due to high smoking rates, insomnia, unhealthy eating habits and a sedentary lifestyle, side effects of psychotropic drugs, and lack of social support (Firth et al., 2016, 2019; McKibbin et al., 2014; Teasdale et al., 2019). At an organizational level, implementation is hampered by lack of priority, support, financial resources, lack of knowledge and training of employees, and mental health worker's (MHW) personal characteristics, such as their lifestyle and personality (Deenik et al., 2020, 2022; Lodder et al., 2019). Lastly, it remains unknown how to successfully implement evidence-based PA interventions in day-to-day practice (Czosnek et al., 2019; Deenik et al., 2019; Firth et al., 2020).

Addressing these barriers is crucial for the implementation of PA interventions in day-to-day practice. MHWs are hypothesized to be pivotal in overcoming these barriers. They often play an important role in the daily lives of people with SMI, serve as role model for lifestyle choices, and might help facilitate a supporting environment for becoming physically active (Deenik et al., 2018; Frank et al., 2000). Therefore, we designed Muva, an intervention package that aimed to lower barriers for PA by primarily targeting the MHW to increase PA of people with SMI (Koomen et al., 2022). Other PA barrier decreasing elements of Muva were a serious game app, lifestyle education, and optimization of the medication regime. The serious game 'Muva' (www.muvaproject.nl) was incorporated since eHealth and gamification can help with goal setting, monitoring, and motivating for PA. This is done by sending reminders and rewarding PA in a playful way and might lower barriers for people with SMI in outpatient settings to become and stay physical active (Firth et al., 2020; Koomen et al., 2020). Lifestyle education was provided about sleep, healthy eating and smoking cessation to improve participants' physical condition. Moreover, a medication review was performed to optimize the medication regimen aiming to lower barriers caused by psychotropic medication, such as sedation, extrapyramidal side effects and weight gain (Firth et al.,

2016).

Muva was implemented in the day-to-day practice of a supported housing organization for people with SMI. In a supported housing organization MHWs are closely involved with people with SMI and support them in their rehabilitation by giving assistance in several domains in peoples' lives such as housing and daily activities to promote independence. In this pragmatic stepped wedge cluster randomized trial, we aimed to evaluate Muva in relation to changes in social functioning and secondary outcomes quality of life, psychiatric symptoms, PA, BMI, waist circumference, and blood pressure. In addition, we assessed if the change in social functioning was associated with MHW's characteristics. Social functioning was chosen as primary outcome since people with SMI often face serious challenges in social functioning and have difficulties in social interactions, relationships, and societal roles (Hoof et al., 2014; Patel et al., 2018). Improving social functioning is therefore crucial for the social reintegration of people with SMI. We hypothesized that Muva would improve social functioning and other outcome measures by involving participants and their MHWs in PA activities together. This is because PA interventions have demonstrated effectiveness in improving social functioning through mitigating psychiatric symptoms, improving self-esteem, and fostering social interaction during the activities themselves (Czosnek et al., 2019; Firth et al., 2020; Franco et al., 2015; Mason & Holt, 2012; Purgato et al., 2023; Rodriguez-Ayllon et al., 2023). Furthermore, we hypothesized that participants with physically active and conscientious MHWs improved their social functioning more than participants with physically less active and less conscientious MHWs.

2. Methods

The protocol is reported according to the CONSORT guidelines (Hemming et al., 2018). The full study protocol is previously described and can be found elsewhere (Koomen et al., 2022)

2.1. Study design and setting

This study is a pragmatic stepped wedge cluster randomized trial that was conducted between January 2021 and November 2022. People with SMI were recruited from supported housing organization Lister and mental health organization Altrecht. Physical measurements were performed in the University Medical Centre Utrecht in The Netherlands.

Supported housing organization Lister consists of a total of 30 teams. Out of these teams, 12 teams were willing to participate in this study. Based on their location, they were divided into four clusters to prevent spillover effects and contamination since nearby teams work closely together. Table 1 describes the study design. In a stepped-wedge cluster-randomized trial, randomization takes place at the cluster level prior to the start of the trial. Clusters are randomized for the order in which they cross over from the control to the intervention of interest. If it takes time for an intervention to take effect or to be implemented, a wash-in period can be applied between the control and intervention period (Hemming et al., 2015). This design was chosen since it allows for a stepped implementation of the intervention, which gives time for the research team and the organization to implement the intervention. Additionally, the organization aimed to implement the intervention within reasonable time for all their clients to improve their care. Therefore, a randomized controlled trial design was not suitable and ethical. As shown, all clusters started with a control period. After three months the first cluster started with the intervention with a wash-in period, and the other two intervention clusters followed with an interval of three months.

2.2. Deviations from the protocol

As described in the study protocol (Koomen et al., 2022), we planned to randomize all four clusters to decide the order of the start of the intervention, and which one cluster would be the control group during the entire study period. However, the supported housing organization selected, based on the availability of staff, one cluster to be the control cluster. In accordance with the protocol, we subsequently randomized the three intervention clusters to decide the order of the start of the intervention. In addition, during the recruitment period we experienced difficulties in recruiting participants in the control cluster. To ensure enough power for the secondary outcome measures, in which only baseline and follow-up measurement were included, we recruited extra participants from mental health organization Altrecht, which serves a similar population. These participants were only assessed at $t = 9$ and $t = 21$. Finally, the last measurement was obtained via online questionnaires instead of a hospital visit to mitigate planned high dropout rates.

2.3. Participants and recruitment

The aim was to recruit 100 participants and their MHWs at the start of the trial. The sample size calculation was done for the primary outcome measure social functioning, and assumed an intra-cluster correlation of 0.1, between-level correlation of 0.8, and standard deviation of 9.0. Anticipating a 30% dropout rate, simulations indicated that with measurements at seven time points in 100 participants, the study will have a power of 0.93 to detect a minimum increase of 3 points in the SFS after one year.

Participants were enrolled through their primary MHW, who were provided with study instructions, eligibility criteria and flyers by the research team. The participating teams were aware of the randomization schedule. The primary MHW informed their clients about the study and if they were interested in participation the client was referred to the research team. The research team informed the participant about the study and enrolled the participant if they met the inclusion criteria. Once participants were willing to participate, their MHW was also asked to participate. One MHW could have more than one client that participated in the study. Participants were eligible if they were ≥ 16 years old, diagnosed with SMI (i.e., a psychiatric disorder classified by the DSM-5 causing serious limitations in psychosocial functioning for a duration of ≥ 2 years), were willing to give informed consent, and could read and speak Dutch. Participants were not eligible for inclusion if, according to their MHW, their psychiatric condition hindered informed consent or/and participation in the intervention. As our goal was to implement the intervention across all participating teams, no exclusion criteria based on the current PA level and the ability to engage in PA were applied, recognizing that individuals experiencing physical constraints can often still participate in alternative, adapted ways. MHWs were included when

they were willing to participate and could give informed consent and read and speak Dutch. All participants were informed about the study and asked for written consent.

2.4. Intervention and control condition

Table 2 gives an overview of Muva. The intervention was not only designed for the participants and MHWs that participated in this study but targeted all the people with SMIs and MHWs of the intervention cluster teams, since the aim was to implement this intervention into routine day-to-day care. Hence, the intervention was delivered at cluster level. At the start of the intervention, the research team gave a workshop explaining the importance of PA for people with SMI with emphasis on being a healthy role model and participating in activities together. All the intervention components were explained and MHWs were trained to perform the PA check. The components of the PA check were explained and during the training all MHWs filled out the PA check. The results of the PA check were discussed and several examples were explained in detail. The MHWs were motivated to perform the PA check with all their clients and themselves. During the PA check participants and their MHWs set PA and other lifestyle goals. Based on these goals, they determined which Muva activities they wish to engage in. They also discussed any possible barriers and how to overcome these, for example by performing activities together or buying sport clothes. In this way every participant had their personalized plan tailored to their individual needs.

They were also encouraged to do active guidance meetings. Guidance meetings between the MHW and participant are part of care as usual and are at least weekly. The lifestyle courses were provided by trained MHWs, who had at least a degree in applied sciences. The MHWs received an one day training from the member of the research team and the first lifestyle course was given by a member of the research team together with two trained MHWs from the cluster. Subsequent editions were led by the two trained MHWs. The sports activities were provided by MHWs or a sport coach. The manager of the team decided if a sport coach was hired or if MHWs were allocated time to conduct the sport activities. Prior to the start of the intervention a medication review was performed during a multidisciplinary team meeting involving a psychiatrist, a psychiatric trainee, and a pharmacist specialized in psychotropics. If applicable, medication advice was given to the treating psychiatrist or general physician. The medication review was done to optimize the medication regime and to lower potential barriers posed by psychotropic medication on increasing physical activity.

Participants in the control condition received care as usual, which encompasses rehabilitation care that focusses on supported housing, (voluntary) employment, and providing support to people with SMI in achieving independent living. In order to establish an active control condition throughout the study, a general healthy lifestyle campaign

Table 1

Design of the pragmatic stepped wedge cluster randomized controlled trial. Control period marked grey, wash-in period marked black, and intervention period marked white. Time in months. Q = online questionnaire, IHM = in hospital measurement with questionnaires and physical measurements, QM = online questionnaire for mental health workers. T = 0 was January 2021, and T = 21 was October 2022. MHW = mental health worker.

Time in months →	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Cluster 1	Q			IHM						Q			Q			IHM			Q			Q
Cluster 2	Q			Q			IHM						Q			Q			IHM			Q
Cluster 3	Q			Q			Q			IHM						Q			Q			IHM
Cluster 4	Q			IHM						Q			Q			IHM			Q			Q
MHW	QM																					

Table 2
Overview of the Muva intervention package.

Phase	Activities	Targeted at	Provided by
Step 1: Evaluating PA and goal setting	<ul style="list-style-type: none">• PA check to:<ul style="list-style-type: none">◦ Evaluate amount of PA◦ Assess barriers and opportunities◦ Set goals• Serious game ‘Muva’ for goal setting, reminders and motivation	MHWs and participants	Trained MHWs
Step 2: Participating in PA activities, lifestyle courses, and medication review	<ul style="list-style-type: none">• Weekly group sports activities: e.g., group walks, yoga, boxing, fitness, football. Mostly held in face-to-face meeting, but also online via live videoconferencing.• Weekly guidance meetings in an active way, e.g., during a walk or a bike ride• Lifestyle education: a. Healthy food program: a five-week course in which participants learn the basics of healthy food and try to improve their eating habitsb Improve sleeping program: a 6-week insomnia cognitive behavioral therapy course in which participants learn to improve their sleep qualityc Smoking cessation program: an 8-week course with elements of cognitive behavioral therapy in which participants do an attempt to quit smokingd Individualized food advice: dietary advice by filling in the Dutch Healthy Diet Index, a questionnaire based on the nutrition advice of the Dutch center for nutrition• Medication review	MHWs and participants Participants	MHWs and sport coaches MHWs Trained MHWs in collaboration with the research team A team of a psychiatrist, a psychiatric trainee, and a pharmacist specialized in psychotropics

was implemented at the supported housing organization. This campaign involved posting various news messages promoting a healthy lifestyle on the organization’s website, directed at MHWs. It did not include any specific PA interventions for people with SMI. Participants in the control condition were not in contact with MHWs from the intervention condition, since they are based in different teams in different areas of the region Utrecht. There were regular meetings with the teams from the control condition to ensure no extra PA or lifestyle activities were organized.

Psychiatric care, for example the prescription of psychotropic drugs, was given by a psychiatrist or the general practitioner.

2.5. Measurements and outcomes

Table 1 provides an overview of the timing of the measurements and Table S1 in the supplementary material provides an overview of the

measurements. The research team and the participants were not blinded for treatment condition and the measurements.

2.5.1. Outcomes in participants

The primary outcome was social functioning as measured by the Social Functioning Scale (SFS) with the domains social withdrawal, interpersonal communication, independence competence, independence performance, and recreation (Birchwood et al., 1990). Secondary outcomes were quality of life measured with the WHOQoL-BREF (Harper, 1996), number of psychiatric symptoms measured with the Brief Symptom Inventory (BSI) (Derogatis & Melisaratos, 1983), PA in multiples of the resting metabolic rate (METs) measured with the International Physical Activity Questionnaire Short Form (IPAQ-SF) (Lee et al., 2011), Body Mass Index (BMI; kg/m2), waist circumference, and blood pressure (mean arterial pressure).

2.5.2. Mental health workers

MHWs were assessed on their PA and lifestyle habits measured with the IPAQ-SF, the Dutch Healthy Diet Index (Looman et al., 2017), and questions on smoking status, drinking habits, and BMI, and their personality traits, as measured with the NEO five-factor inventory (Costa Jr. and McCrae, 2004).

2.5.3. Intervention fidelity

The implementation of the intervention was assessed by tracking the types of PA activities offered, the frequency of lifestyle courses, and the proportion of participants whose guidance plans include PA goals.

2.6. Statistical analyses

Demographics and baseline measures were presented using numbers, percentages, means and standard deviations. Differences between intervention and control clusters and between participants that participated during the full study period and dropouts were analyzed using ANOVA for continuous variables and chi-square tests for categorical variables.

For all outcomes, an intention-to-treat analysis was done. In accordance with the planned analyses, for the primary outcome a mixed-effects linear regression model was performed for the five domains of social functioning separately (Koomen et al., 2022). This model included all seven time points and took into account the clustering of outcome measurements within individuals and clusters using random effects. Possible confounding factors age, gender and diagnostic subgroups were added as fixed effects to investigate the effect of Muva on social functioning. Diagnostic subgroups with less than five participants were combined in the category ‘other’. There were no missing data in the covariates, thus multiple imputation was not performed. Sensitivity analyses included additional covariate analysis as fixed effects, which was done with the variables cluster assignment, actual attendance at lifestyle education and medication changes (yes/no). An extra sensitivity analysis was done using the actual time point of the measurement as timescale rather than the planned timepoint, since participants were sometimes measured later (mean 24.5, SD = 32.6 days) than planned, often because of personal circumstances such as disease severity. To assess if MHW’s lifestyle and their character trait conscientiousness were associated with their clients’ change in social functioning, sensitivity analyses with MHW’s PA and the character trait conscientiousness as additional fixed effects were performed. For the secondary outcomes, a mixed-effects linear regression model including age, gender and the baseline measurement of the dependent variable as fixed effects, and diagnostic subgroups as random effects was performed. A Bonferroni correction was done to correct for multiple testing, such that instead of a $p = 0.05$, a $p < 0.01$ was considered statistically significant. IBM SPSS statistics 27 and JASP version 0.17.2.1 were used for analyses.

3. Results

At enrollment cluster one had 193 clients, cluster two 125 clients, cluster three 188 clients and cluster four 121 clients. At the time of randomization, cluster one had 27 participants, cluster two had 27 participants, cluster three had 30 participants, and cluster four had 38 participants. Fig. 1 shows the CONSORT flow chart with an overview of the participant flow and dropout. Participants who dropped out from a measurement were asked at the following measurement to continue participating, thus participant numbers fluctuated during the study. After three months, cluster one started with the intervention, followed by cluster two and three with intervals of three months.

Table 3 shows the baseline characteristics of participants and differences between the intervention and control clusters. Most participants were male, lived independently, and received treatment from a psychiatrist. Most participants were diagnosed with a psychotic spectrum disorder, followed by an autism spectrum disorder. These characteristics correspond to the average representation of the population at the supported housing organization. Participants in the control cluster were more often treated by a psychiatrist and regarding social functioning, scored higher on independence performance. Table S2 in the supplementary material shows the measurements of the MHWs.

3.1. Dropout analysis

Participants who dropped out ($n = 38$, 31.7%) were older (52.0 vs. 43.3 year, $p < 0.01$) than participants that continued participating in the study (Table S3). Other characteristics did not differ.

3.2. Intervention fidelity and adherence

In cluster one, PA goals were reported in 35.5% of the guidance plans, and numerous group sport activities were organized: walks, yoga, boxing, football, basketball, and fitness. In cluster two, PA goals were reported in 92.0% of the guidance plans, and a sport coach was hired to do sports activities with participants and group sport activities as swimming and Pilates were organized. In cluster three, PA goals were reported in 18.0% of the guidance plans. No extra group sport activities were offered, but participants could join free sports activities in the neighborhood. All intervention clusters could also participate in online sport lessons via live videoconferencing. Regarding lifestyle education, eight participants (10.4%) participated in the healthy food program, six participants (7.8%) participated in the improve sleeping program, and six participants (7.8%) participated in the smoking cessation program. Only two participants (2.6%) used the Muva serious game. No harms or unintended effects of the intervention were reported.

3.3. Medication review

A medication review was performed for 57 participants (69.5%) in the intervention clusters, seven participants (8.5%) did not give consent for the medication review and eighteen participants (17.8%) did not use any medication. For 32 participants (69.6%) we recommended changing medication, and for eleven participants (19.3%) we advised considering a medication change (Table S4). For eight participants (25.0%) the medication advice was entirely followed up on, and for four participants (12.5%) the advice was partly followed up on. The medication advice could also include two or more suggestions to modify psychotropics. When partially followed, at least one of the recommendations was implemented. For the majority of the participants (62.5%) the medication advice was not followed up on.

3.4. Changes in primary outcome social functioning

The analyses were done according to the allocated schedule. Table 4 lists the results of the mixed-effects linear regression on social

functioning and shows a clinically significant improvement of social functioning on the domains interpersonal communication ($B = 9.07$, $CI = 4.05-14.09$) (Fig. 2), and independence competence ($B = 5.03$, $CI = 2.49-7.56$) (Fig. 3) for Muva in comparison to care as usual. The variable time was statistically significant in the analysis on interpersonal communication, indicating that without the intervention interpersonal communication deteriorates over time. Results were robust for sensitivity analysis on cluster, medication changes, participation at lifestyle education and actual time of measurement (Table S5 and S6).

3.4.1. Association with MHW's characteristics and clients' change in social functioning

The physical activity and the MHW's character trait conscientiousness were not associated with their client's change in social functioning (Table S6).

3.5. Changes in secondary outcomes

Muva improved quality of life ($B = 0.43$, $CI = 0.25-0.61$, $p = 0.05$), however, this outcome was not statistically significant after correction for multiple testing. No improvements were found for the other secondary outcomes (Table S7 and S8).

4. Discussion

The aim of this study was to investigate the effects of Muva compared to care as usual on social functioning and secondary outcomes in people with SMI, and to assess if the change in social functioning was associated with MHW's characteristics. We found a clinically significant improvement of social functioning on the domains interpersonal communication and independence competence. No changes were found for the other domains of social functioning or in the secondary outcomes. Participants' change in social functioning was not associated with their MHW's characteristics. These results are of clinical significance since people with SMI often face serious challenges in social functioning and experience difficulties effectively managing social interactions, relationships, and societal roles (Hoof et al., 2014; Patel et al., 2018). Improving social functioning is crucial for the social reintegration of people with SMI.

Previous research on lifestyle interventions in supported housing facilities found varying results on social functioning (Koomen, Van der Horst, et al., 2022), with one study reporting an improvement in social functioning measured with the Global Assessment of Functioning Scale (Forsberg et al., 2010). Although measured with another scale, our results are in line with a Dutch study that found improved social functioning from a lifestyle intervention in SMI inpatients (Deenik et al., 2018). Interestingly, we only found an improvement of social functioning in two domains of the social functioning scale: interpersonal communication and independence competence. In the intervention, group sessions were held, and the additional social interaction might explain the improvement in interpersonal communication, as was also found in systematic reviews of qualitative assessments of PA interventions (Franco et al., 2015; Mason & Holt, 2012). In addition, the increased self-esteem due to participation in the intervention might have led to progress in independence competence as PA can improve self-esteem (Franco et al., 2015; Mason & Holt, 2012; Rodriguez-Ayllon et al., 2023; Sonstroem and Morgan, 1989). Conversely, participants did not improve in the domain independence performance. This finding might be explained from the self-determination theory (Deci & Ryan, 2000) and the self-efficacy theory (Bandura, 1978), that describe that people must first perceive that they can perform certain behavior prior to performing and adopting this behavior. Behavioral change is a gradual process with small changes, which is intermediated by several mediational pathways, including self-efficacy. Self-efficacy is shown to be an important predictor for behavioral change initiation and maintenance (Crain & Martinson, 2010). Thus, it may require more time for

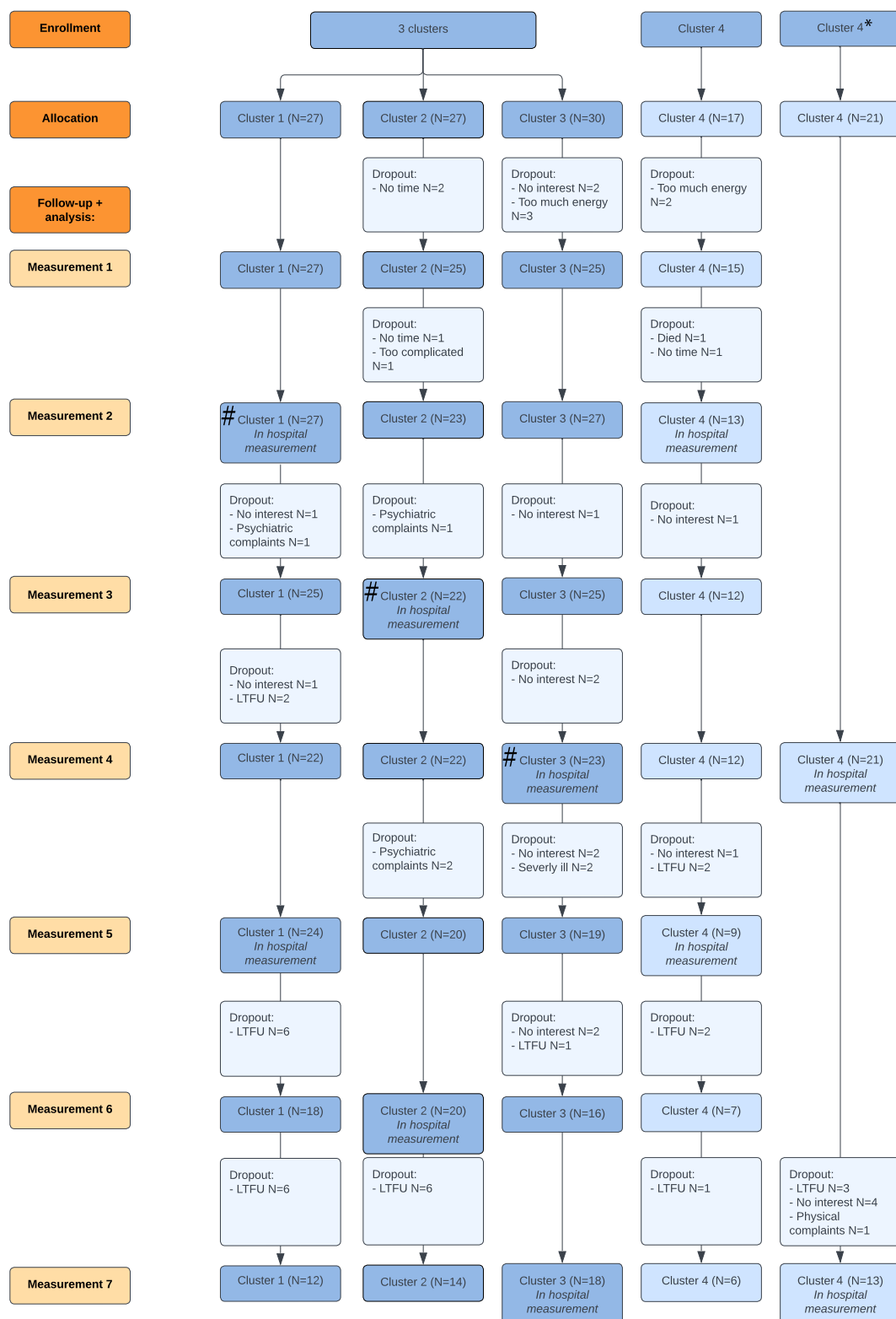


Fig. 1. CONSORT flow chart: Overview of patient flow and dropout. * = extra inclusions in cluster four. # after this measurement the intervention started.

Table 3

Overview of baseline measurements of participants and differences between intervention and control clusters. BMI = body mass index, MET = multiples of resting metabolic state, N = number of participants in the given category, p = p-value, SD = standard deviation. 1 = missing data for 10 participants in the intervention and 4 participants in the control, 2 = missing data for 12 participants in the intervention and 5 participants in the control, 3 = missing data for 13 participants in the intervention and 6 participants in the control, 4 = missing data for 12 participants in the intervention and 3 participants in the control, 5 = missing data for 15 participants in the intervention and 5 participants in the control, 6 = missing data for 17 participants in the intervention and 5 participants in the control, 7 missing data for 27 participants in the intervention and 8 participants in the control. Missing data on questionnaires occurred since participants only partly filled in the questionnaire. Missing data on physical measurements occurred since not all participants were able to come to the hospital for measurements.

Variables	Intervention clusters N = 83		Control cluster N = 37		p
	N (%)	Mean (SD)	N (%)	Mean (SD)	
Age (year)		46.5 (13.6)		45.0 (13.5)	0.58
Gender					0.25
Male	51 (61.4)		28 (75.7)		
Female	30 (36.2)		9 (24.3)		
Other	2 (2.4)		0 (0.0)		
Lives independently	52 (64.2)		30 (81.1)		0.07
Is treated by psychiatrist	51 (63.7)		32 (88.9)		<0.01
Primary diagnosis					0.32
Psychotic spectrum disorder	24 (28.9)		18 (50.0)		
Autism spectrum disorder	25 (30.2)		5 (13.8)		
Personality disorder	10 (12.0)		2 (5.6)		
Depressive disorder	8 (9.7)		5 (13.8)		
Bipolar disorder	6 (7.2)		2 (5.6)		
Substance abuse disorder	4 (4.8)		1 (2.8)		
Post-traumatic stress disorder	3 (3.6)		2 (5.6)		
Anxiety disorder	2 (2.4)		1 (2.8)		
Attention deficit disorder	1 (1.2)		0 (0.0)		
Social functioning scale ¹					
Withdrawal		97.1 (11.7)		100.9 (12.2)	0.13
Interpersonal communication		104.0 (10.4)		108.4 (11.2)	0.05
Independence competence		100.8 (10.1)		105.7 (10.2)	0.02
Independence performance		102.6 (9.8)		107.6 (7.1)	<0.01
Recreation		113.9 (14.3)		119.2 (12.8)	0.07
Brief symptom inventory ²		23.4 (12.7)		22.8 (13.5)	0.81
Quality of life ³		3.1 (1.0)		3.5 (0.9)	0.11
IPAQ total PA in METs ⁴		2525.4 (2307.8)		2307.8 (2130.9)	0.72
Is a smoker	38 (45.8)		15 (40.5)		0.59
Drinks alcohol	44 (53.0)		16 (43.2)		0.32
BMI ⁵		28.0 (6.3)		27.2 (4.0)	0.53
Waist circumference in cm ⁶					0.16
Females		98.9 (14.3)		94.3 (12.6)	
Males		101.7 (18.6)		96.6 (14.9)	
Mean arterial blood pressure ⁷		101.3 (12.9)		99.3 (11.7)	0.51

Table 4

Results of the mixed-effects linear regression on social functioning with N = 99. Analysis is corrected for time effects, age, gender and diagnostic subgroups. B = coefficient, CI = confidence interval, p = p-value.

Variables	Mixed-effects linear regression		
	B	CI	p
Withdrawal			
Intercept	93.97	85.03–102.90	<0.01
Intervention	–1.73	–4.13–0.68	0.16
Time	0.45	–0.01–0.91	0.05
Interpersonal communication			
Intercept	120.69	106.94–134.43	<0.01
Intervention	9.07	4.05–14.09	<0.01
Time	–1.44	–2.42–0.46	<0.01
Independence competence			
Intercept	105.84	96.80–114.87	<0.01
Intervention	5.03	2.49–7.56	<0.01
Time	–0.62	–1.11–0.12	0.02
Independence performance			
Intercept	107.56	97.46–117.66	<0.01
Intervention	–0.43	–2.90–2.05	0.74
Time	0.27	–0.20–0.75	0.26
Recreation			
Intercept	110.21	98.41–122.01	<0.01
Intervention	–3.16	–6.82–0.51	0.09
Time	0.48	–0.23–1.18	0.19

participants to actually perform activities independently and to improve in their independence performance and PA, than to improve their independence competence.

Moreover, in line with previous research on lifestyle interventions in supported housing facilities, no improvement in quality of life was found (Koomen, Van der Horst, et al., 2022). We also did not find a change in psychiatric symptoms, which contrasts a meta-review on lifestyle psychiatry (Firth et al., 2020) that did find a decrease in symptoms for PA interventions for depression, and anxiety disorders. Yet, for psychotic disorders a symptom decrease was found only when PA was performed for at least 90 min of moderate-to-vigorous activity per week. These conflicting results could be attributed to the heterogeneity in diagnoses and the less structured nature of the Muva intervention. Unlike previous studies in which all participants had e.g. twice weekly PA moments, the Muva intervention was tailored to the personal goals of participants (Bartels et al., 2015; Daumit et al., 2013). Therefore, PA goals differed between participants. Moreover, no increase in PA at follow-up in comparison to the baseline measurement was found. This suggests that the improvement of social functioning was not mediated by PA, which was also found by Deenik et al. in a lifestyle intervention for inpatients with SMI, but might be better explained by an improvement in self-efficacy (Deenik et al., 2018). In addition, we did not find any improvements in BMI, waist circumference, and blood pressure. Previous literature found inconsistent results on these outcomes in people with SMI (Koomen, Van der Horst, et al., 2022; Stubbs et al., 2018). The absence of a change in these parameters might be explained by the nature and setting of our intervention. Participants could choose what activities they would participate in depending on their personal goals, in contrast with previous RCTs in which participants received structured exercise sessions multiple times a week (Bartels et al., 2015; Daumit et al., 2013). For improvements in psychiatric symptoms and physical measurements, a more structured intervention with a minimum of twice-weekly PA sessions of moderate-to-vigorous activity might be needed.

MHW's PA and personality were not associated with their clients' change in social functioning. This was in contrast to our hypothesis since previous cross-sectional studies showed that healthier lifestyle habits of the health care worker were associated with lifestyle counseling and referral (Deenik et al., 2022; Fie et al., 2013), and the character trait conscientiousness was associated with better rehabilitation outcomes (Lodder et al., 2019). A connection between the MHW's and client's

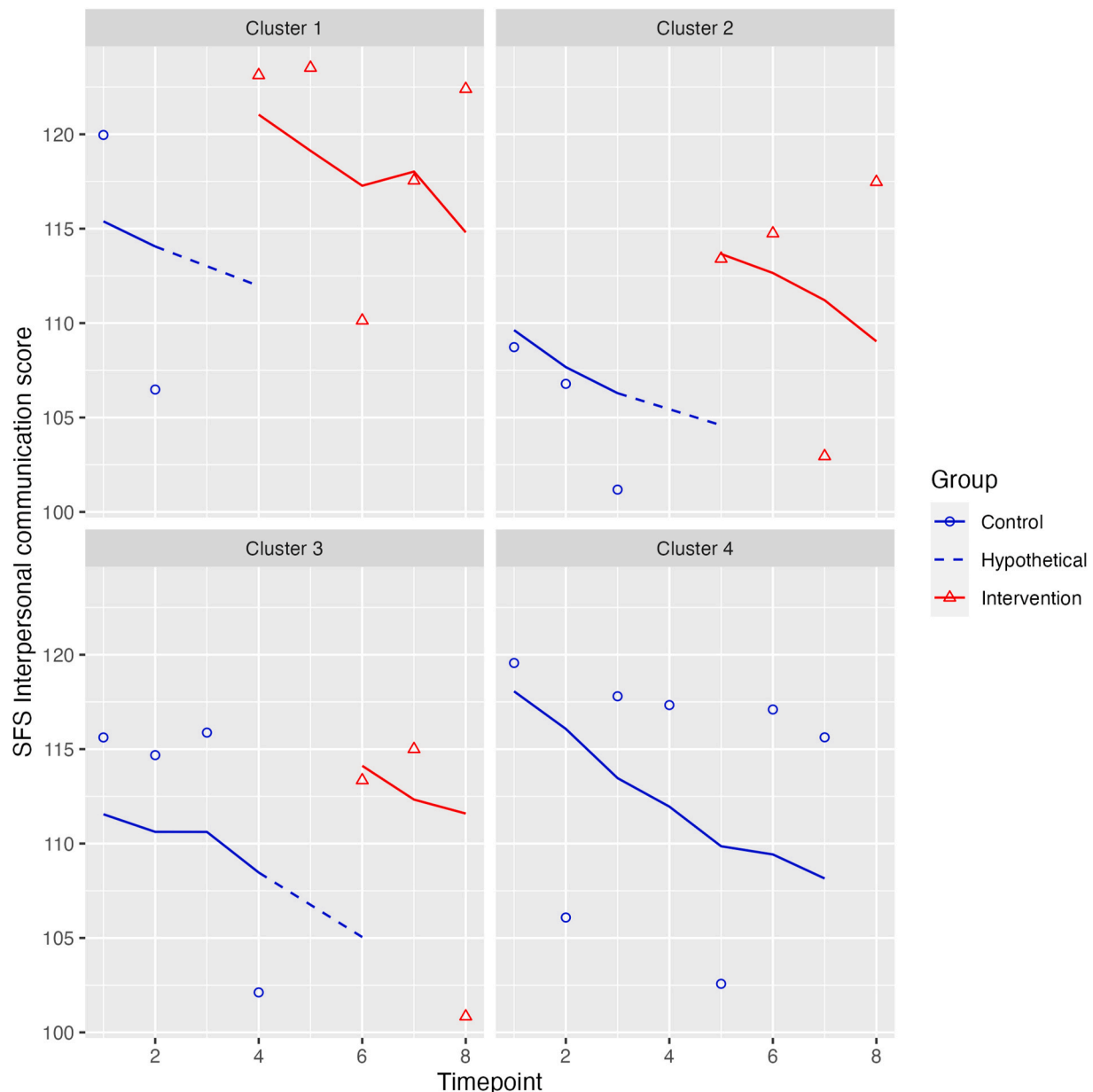


Fig. 2. Graphical overview of social functioning interpersonal communication. Control = care as usual, hypothetical = hypothesized progress without the intervention, intervention = actual progress once the intervention started.

personalities might be more important than specific traits of the MHW. To our knowledge, there are no previous intervention studies that assessed the association between the MHW's characteristics and the change in client's outcomes. Future studies should investigate this with larger sample sizes.

4.1. Strengths and limitations

The strength of this study is that with the design of a pragmatic stepped wedge trial we were able to closely align with the participants' and organization's needs, thereby reflecting the reality of the challenges that people with SMI and their MHWs experience daily to engage in PA. This study contributes to the evidence on the efficacy and implementation of PA interventions in clinical practice, which is needed to validate the evidence from RCTs into routine mental health care (Czosnek et al., 2019; Deenik et al., 2019; Firth et al., 2020). However, our study also has limitations. Firstly, there were difficulties with the implementation of Muva. Not all participants received a PA check with

their MHWs, which is reflected by the low percentages of PA goals in guidance plans in cluster one and three. Second, in cluster three no extra sport activities were organized. There were sport activities in the neighborhood, but these were less accessible than activities provided by the supported housing facility. Third, in all clusters, only few participants participated in the lifestyle education courses and the Muva app was only used by two participants. These implementation difficulties were caused by several factors. The study took place during the COVID-19 pandemic, which caused logistic difficulties, e.g., group sessions that could not take place in person, but were held online, sometimes resulted in staff shortages, and gave extra pressure on teams since participants sometimes experienced more symptoms. In addition, at some locations staff were not given extra time for their extra responsibilities regarding the intervention, and were consequently unable to fulfill all their responsibilities, which caused lifestyle courses only to be held once. Moreover, some locations prioritized Muva lowest among all clinical responsibilities. Previous studies on lifestyle interventions in supported housing settings also showed implementation difficulties

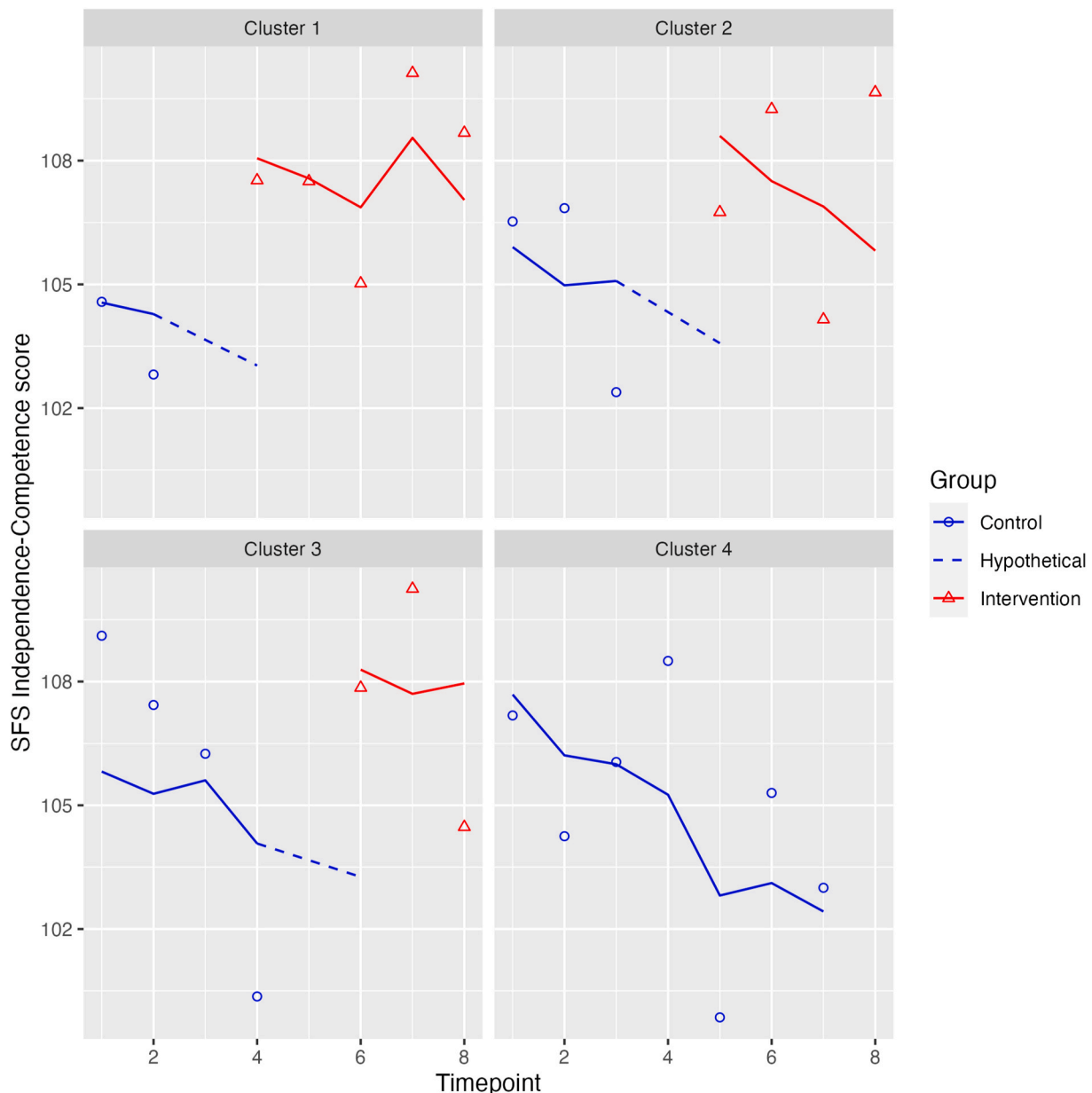


Fig. 3. Graphical overview of social functioning independence competence. Control = care as usual, hypothetical = hypothesized progress without the intervention, intervention = actual progress once the intervention started.

related to the MHW as lack of time, insufficient experience with motivating people to change their lifestyle habits and conflicting role expectations (Koomen, Van der Horst, et al., 2022). The low uptake of the intervention may also be attributed to the fact that the intervention elements were not sufficiently tailored to the needs and preferences of the participants. Discussions during monthly research meetings revealed some of the challenges with implementing the Muva serious game, such as participants' low smartphone availability and MHWs' concerns about the game's appeal. A second limitation is that cluster four was not randomized, and this could have caused selection bias, yet, with the stepped wedge design all participants provided their own control condition which limits bias, and we controlled for age, gender, and diagnostic subgroups. However, bias caused by unmeasured confounding factors may still exist. Yet the results on social functioning remained robust in an additional sensitivity analysis excluding the control group (Table S9). Thirdly, there might have been selection bias since participants and MHWs that are interested in PA might have been more willing to participate in this study. Fourthly, the research team and the

participants were not blinded for treatment condition and the measurements, which might have caused bias. However, it is not possible to blind participants in a PA intervention. Fifthly, an exploration into the factors contributing to the reluctance of the remaining eighteen teams at Lister to participate in the study was not conducted, which could have provided additional insights into generalizability of the results. In particular, implementation of the intervention may be more challenging in clusters not willing to participate in a trial, resulting in potential overestimation of the intervention effects. Sixthly, we did not have data on actual PA of participants, because no PA trackers were used, and we did not have access to the amount of guidance hours. Therefore, we were unable to do a sensitivity analysis to gain insight in the role of PA changes and guidance hours on social functioning. Thus, we were unable to estimate whether the change in social functioning resulted from the lifestyle components of Muva or from a potential rise in social interactions and guidance hours resulting from participation in Muva. Nevertheless, in this study population, where participants often experience chronic symptoms, we observed a positive change in social

functioning. Conversely, during the usual course of supported housing care, we observed a deterioration in interpersonal communication. Finally, the limited number of clusters randomized reduces the power of the stepped-wedge design. However, because of repeated measurements within participants, dependent outcomes within individuals are likely to be more important than within clusters.

Our results show that despite encountering implementation challenges and having a less structured approach compared to prior RCTs (Bartels et al., 2015; Daumit et al., 2013), Muva improved social functioning compared to care as usual. However, results might have been better when the intervention was implemented more successfully. Our results may be generalized to other supported housing facilities and flexible assertive community treatment teams. Yet, future studies or organizations that try implementing PA interventions in day-to-day practice should investigate and address implementation challenges to improve implementation, intervention adherence, and outcomes.

5. Conclusions

Muva improved social functioning on the domains interpersonal communication and independence competence in people with SMI compared to care as usual. MHW's PA and personality were not associated with their clients' change in social functioning. Yet, implementation difficulties were experienced and strategies to solve implementation barriers are needed for improved integration of PA interventions in day-to-day practice.

Funding

We received funding from the governmental funding body NWO [Aut.19.013] for the conduct of the study; The Dutch Heart Association [2019T101]; Agis Innovation Fund [2019–17]; and health insurer VGZ for the development of the Muva serious game. NWO, the Dutch Heart Association, Agis Innovation Fund, and VGZ have not and will not participate in the conduct, data collection, analysis, and interpretation of this study and will not have any role in the decision to submit results for publication.

Ethics approval and consent to participate

This study was approved by the Medical Ethical Committee of the University Medical Centre Utrecht (20–628/C). All participants were asked for consent to participate. This study was conducted according to the principles of the Declaration of Helsinki (amended version in October 2013) and following the Good Clinical Practice guidelines from the European Medicines Agency (ICH E6, R2) and the Medical Research Involving Human Subjects Act (WMO).

CRedit authorship contribution statement

Lisanne Elisabeth Maria Koomen: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ilona Hendrika Theodora van de Meent:** Writing – review & editing, Writing – original draft, Project administration, Investigation, Data curation. **Jeroen Deenik:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Edwin van Dellen:** Writing – review & editing, Supervision, Methodology, Investigation. **Hugo Gerard Schnack:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Cornelis Hendrikus van Werkhoven:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Wilma Elisabeth Swildens:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Berno van Meijel:** Writing – review & editing, Methodology, Investigation,

Funding acquisition, Conceptualization. **Wouter Staal:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Frederike Jörg:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Floortje Scheepers:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Wiepke Cahn:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.mhpa.2024.100601>.

References

- Bandura, A. (1978). Self-efficacy: Toward a unifying theory of behavioral change. *Advances in Behaviour Research and Therapy*, 1, 139–161. <https://doi.org/10.1037/0033-295X.84.2.191>
- Bartels, S. J., Pratt, S. I., Aschbrenner, K. A., Barre, L. K., Naslund, J. A., Wolfe, R., Xie, H., McHugo, G. J., Jimenez, D. E., Jue, K., Feldman, J., & Bird, B. L. (2015). Pragmatic replication trial of health promotion coaching for obesity in serious mental illness and maintenance of outcomes. *American Journal of Psychiatry*, 172(4), 344–352. <https://doi.org/10.1176/appi.ajp.2014.14030357>
- Birchwood, M., Smith, J., Cochrane, R., Wetton, S., & Copestake, S. (1990). The Social Functioning Scale. The development and validation of a new scale of social adjustment for use in family intervention programmes with schizophrenic patients. *British Journal of Psychiatry*, 157(12), 853–859. <https://doi.org/10.1192/bjp.157.6.853>
- Costa Jr, P. T., & McCrae, R. R. (2004). Chapter 9: The revised NEO personality inventory (NEO-PI-R). In the SAGE Handbook of personality theory and assessment: Volume 2 — personality measurement and testing. <https://doi.org/10.4135/9781849200479.n9>
- Crain, A. L., & Martinson, B. C. (2010). The long and winding road to physical activity maintenance NIH public access. *American Journal of Health Behavior*, 34(6), 764–775.
- Czosnek, L., Lederman, O., Cormie, P., Zopf, E., Stubbs, B., & Rosenbaum, S. (2019). Health benefits, safety and cost of physical activity interventions for mental health conditions: A meta-review to inform translation efforts. *Mental Health and Physical Activity*, 16, 140–151.
- Daumit, G. L., Dickerson, F. B., Wang, N.-Y., Dalcin, A., Jerome, G. J., Anderson, C. A. M., Young, D. R., Frick, K. D., Yu, A., Gennusa, J. V. 3rd, Oefinger, M., Crum, R. M., Charleston, J., Casagrande, S. S., Guallar, E., Goldberg, R. W., Campbell, L. M., & Appel, L. J. (2013). A behavioral weight-loss intervention in persons with serious mental illness. *New England Journal of Medicine*, 368(17), 1594–1602. <https://doi.org/10.1056/NEJMoa1214530>
- Deci, E. L., & Ryan, R. M. (2000). The “what” and “Why” of goal Pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. <https://doi.org/10.1207/S15327965PLI1104.01>
- Deenik, J., Czosnek, L., Teasdale, S. B., Stubbs, B., Firth, J., Schuch, F. B., Tenback, D. E., van Harten, P. N., Tak, E. C. P. M., Lederman, O., Ward, P. B., Hendriksen, I. J. M., Vancampfort, D., & Rosenbaum, S. (2019). From impact factors to real impact: Translating evidence on lifestyle interventions into routine mental health care. *Translational Behavioral Medicine*, 1–4. <https://doi.org/10.1093/tbm/ibz067>
- Deenik, J., Koomen, L. E. M., Scheewe, T. W., van Deursen, F. P., & Cahn, W. (2022). Cardiorespiratory fitness and self-reported physical activity levels of referring mental healthcare professionals, and their attitudes and referral practices related to exercise and physical health. *Journal of Psychiatric Research*, 154, 19–27. <https://doi.org/10.1016/j.jpsychires.2022.07.029>
- Deenik, J., Looijmans, A., Kruisdijk, F. R., & Jörg, F. (2020). De kunst van de lange adem: implementatie van leefstijlinterventies in de ggz. *Tijdschrift voor Psychiatrie*, 62(11), 981–989.
- Deenik, J., Tenback, D. E., Tak, E. C. P. M., Hendriksen, I. J. M., & van Harten, P. N. (2018). Improved psychosocial functioning and quality of life in inpatients with severe mental illness receiving a multidisciplinary lifestyle enhancing treatment. The MULTI study II. *Mental Health and Physical Activity*, 15(10), 145–152. <https://doi.org/10.1016/j.mhpa.2018.10.004>

- Delespaul, P. H. (2013). Consensus over de definitie van mensen met een ernstige psychische aandoening (epa) en hun aantal in Nederland. *Tijdschrift voor Psychiatrie*, 55(6), 427–438.
- Derogatis, L. R., & Melisaratos, N. (1983). The Brief symptom inventory: An introductory report. *Psychological Medicine*, 13(3), 595–605.
- Eather, N., Wade, L., Pankowiak, A., & Eime, R. (2023). The impact of sports participation on mental health and social outcomes in adults: A systematic review and the 'mental health through sport' conceptual model. *Systematic Reviews*, 12(102), 1–27. <https://doi.org/10.1186/s13643-023-02264-8>
- Fie, S., Norman, I. J., & While, A. E. (2013). The relationship between physicians' and nurses' personal physical activity habits and their health-promotion practice: A systematic review. *Health Education Journal*, 72(1), 102–119. <https://doi.org/10.1177/0017896911430763>
- Firth, J., Rosenbaum, S., Stubbs, B., Górczynski, P., Yung, A. R., & Vancampfort, D. (2016). Motivating factors and barriers towards exercise in severe mental illness: A systematic review and meta-analysis. *Psychological Medicine*, 46(14), 2869–2881. <https://doi.org/10.1017/S0033291716001732>
- Firth, J., Siddiqi, N., Koyanagi, A., Siskind, D., Rosenbaum, S., Galletly, C., Allan, S., Cane, C., Carney, R., Carvalho, A. F., Chatterton, M. L., Correll, C. U., Curtis, J., Gaughran, F., Heald, A., Hoare, E., Jackson, S. E., Kisely, S., Lovell, K., ... Stubbs, B. (2019). The Lancet psychiatry Commission: A blueprint for protecting physical health in people with mental illness. *The Lancet Psychiatry*, 6(8), 675–712. [https://doi.org/10.1016/S2215-0366\(19\)30132-4](https://doi.org/10.1016/S2215-0366(19)30132-4)
- Firth, J., Solmi, M., Wootton, R., Vancampfort, D., Schuch, F., Gilbody, S., Torous, J., Teasdale, S., Jackson, S., Smith, L., Eaton, M., Jacka, F., Veronese, N., Marx, W., Ashdown-Franks, G., Siskind, D., Sarris, J., Rosenbaum, S., Carvalho, A., & Stubbs, B. (2020). A meta-review of "lifestyle psychiatry": The role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders. *World Psychiatry*, 19(3), 360–380. <https://doi.org/10.1002/wps.20773>
- Forsberg, K. A., Björkman, T., Sandman, P. O., & Sandlund, M. (2010). Influence of a lifestyle intervention among persons with a psychiatric disability: A cluster randomised controlled trial on symptoms, quality of life and sense of coherence. *Journal of Clinical Nursing*, 19(11–12), 1519–1528. <https://doi.org/10.1111/j.1365-2702.2009.03010.x>
- Franco, M. R., Tong, A., Howard, K., Sherrington, C., Ferreira, P. H., Pinto, R. Z., & Ferreira, M. L. (2015). Older people's perspectives on participation in physical activity: A systematic review and thematic synthesis of qualitative literature. *British Journal of Sports Medicine*, 49(19), 1268–1276. <https://doi.org/10.1136/bjsports-2014-094015>
- Frank, E., Breyan, J., & Elon, L. (2000). Physician Disclosure of healthy personal behaviors improves Credibility and ability to motivate. *Archives of Family Medicine*, 9, 287–290. <https://doi.org/10.1001/archfam.9.3.287>
- Harper, A. (1996). WHOQOL-BREF introduction, administration, scoring and generic version of the assessment. *WHO*, 12(Issue 1). <https://doi.org/10.1177/0013916596281001>
- Hemming, K., Haines, T. P., Chilton, P. J., Girling, A. J., & Lilford, R. J. (2015). The stepped wedge cluster randomised trial: Rationale, design, analysis, and reporting. *BMJ*, 350, 1–7. <https://doi.org/10.1136/bmj.h391>
- Hemming, K., Taljaard, M., McKenzie, J. E., Hooper, R., Copas, A., Thompson, J. A., Dixon-Woods, M., Aldcroft, A., Doussau, A., Grayling, M., Kristunas, C., Goldstein, C. E., Campbell, M. K., Girling, A., Eldridge, S., Campbell, M. J., Lilford, R. J., Weijer, C., Forbes, A. B., & Grimshaw, J. M. (2018). Reporting of stepped wedge cluster randomised trials: Extension of the CONSORT 2010 statement with explanation and elaboration. *BMJ*, 363. <https://doi.org/10.1136/bmj.k1614>
- Hoof, F. van, Erp, N. van, Boumans, J., & Muusse, C. (2014). Persoonlijk en maatschappelijk herstel van mensen met ernstige psychische aandoeningen. In *Trendrapportage*. <https://assets.trimbos.nl/docs/83ffad0a-cf73-4447-aec9-d5dd3033ceff.pdf>
- Koomen, L. E. M., Roke, Y., & Cahn, W. (2020). Evidence-based e-healthtoepassingen op het gebied van leefstijl in de psychiatrie. *Tijdschrift voor Psychiatrie*, 62(11), 992–997.
- Koomen, L. E. M., van de Meent, I. H. T., Deenik, J., van Dellen, E., Schnack, H. G., van Werkhoven, H., Swildens, W. E., van Meijel, B., Staal, W., Jörg, F., Scheepers, F., & Cahn, W. (2022). Muva physical activity intervention to improve social functioning in people with a severe mental illness: Study protocol of a pragmatic stepped wedge cluster randomized trial. *BMC Psychiatry*, 22. <https://doi.org/10.1186/s12888-022-04321-3>
- Koomen, L. E. M., Van der Horst, M. Z., Deenik, J., & Cahn, W. (2022). Lifestyle interventions for people with a severe mental illness living in supported housing: A systematic review and meta-analysis. *Frontiers in Psychiatry*, 13, Article 966029. <https://doi.org/10.3389/fpsy.2022.966029>
- Lee, P. H., Macfarlane, D. J., Lam, T., & Stewart, S. M. (2011). Validity of the international physical activity questionnaire short form. *International Journal of Behavioral Nutrition and Physical Activity*, 8(115), 1–11.
- Lodder, M., Schrijvers, A. J. P., de Leeuw, J. R. J., Brouwer, R. M., & Cahn, W. (2019). Community housing: Functional outcome of severe mental illness is associated with the personality traits of the case manager. *Housing, Care and Support*, 22(2), 106–113. <https://doi.org/10.1108/HCS-10-2018-0026>
- Looman, M., Feskens, E. J. M., De Rijk, M., Meijboom, S., Biesbroek, S., Temme, E. H. M., De Vries, J., & Geelen, A. (2017). Development and evaluation of the Dutch healthy diet index 2015. *Public Health Nutrition*, 20(13), 2289–2299. <https://doi.org/10.1017/S136898001700091X>
- Mason, O. J., & Holt, R. (2012). Mental health and physical activity interventions: A review of the qualitative literature. *Journal of Mental Health*, 21(3), 274–284. <https://doi.org/10.3109/09638237.2011.648344>
- McKibbin, C. L., Kitchen, K. A., Wykes, T. L., & Lee, A. A. (2014). Barriers and Facilitators of a healthy lifestyle among persons with serious and Persistent mental illness: Perspectives of community mental health Providers. *Community Mental Health Journal*, 50(5), 566–576. <https://doi.org/10.1007/s10597-013-9650-2>
- Patel, V., Saxena, S., Lund, C., Thornicroft, G., Baingana, F., Bolton, P., Chisholm, D., Collins, P. Y., Cooper, J. L., Eaton, J., Herrman, H., Herzallah, M. M., Huang, Y., Jordans, M. J. D., Kleinman, A., Medina-Mora, M. E., Morgan, E., Niaz, U., Omigbodun, O., ... Unützer, J. (2018). The Lancet Commission on global mental health and sustainable development. *The Lancet*, 392(9), 1553–1598. [https://doi.org/10.1016/S0140-6736\(18\)31612-X](https://doi.org/10.1016/S0140-6736(18)31612-X)
- Plana-Ripoll, O., Pedersen, C. B., Agerbo, E., Holtz, Y., Erlangsen, A., Canudas-Romo, V., Andersen, P. K., Charlson, F. J., Christensen, M. K., Erskine, H. E., Ferrari, A. J., Iburg, K. M., Momen, N., Mortensen, P. B., Nordentoft, M., Santomauro, D. F., Scott, J. G., Whiteford, H. A., Weyerer, N., ... Laursen, T. M. (2019). A comprehensive analysis of mortality-related health metrics associated with mental disorders: A nationwide, register-based cohort study. *The Lancet*, 394(10211), 1827–1835.
- Plana-Ripoll, O., Weyerer, N., Momen, N. C., Christensen, M. K., Iburg, K. M., Laursen, T. M., & McGrath, J. J. (2020). Changes over time in the Differential mortality Gap in individuals with mental disorders. *JAMA Psychiatry*, 77(6), 648–650. <https://doi.org/10.1001/jamapsychiatry.2020.0334>
- Purgato, M., Cadoret, C., Prina, E., Ferreira, M. C., Del Piccolo, L., Gerber, M., Jordans, M. J. D., Ostuzzi, G., Richards, J., Rudi, D., Vitali, F., Cortese, S., Schena, F., & Barbui, C. (2023). Umbrella systematic review and meta-analysis: Physical activity as an effective Therapeutic Strategy for improving psychosocial outcomes in Children and Adolescents. *Journal of the American Academy of Child & Adolescent Psychiatry*. <https://doi.org/10.1016/j.jaac.2023.04.017>
- Rodriguez-Ayllon, M., Neumann, A., Hofman, A., Voortman, T., Lubans, D. R., Yang-Huang, J., Jansen, P. W., Raat, H., Vernooij, M. W., & Muetzel, R. L. (2023). Neurobiological, psychosocial, and behavioral Mechanisms mediating associations between physical activity and psychiatric symptoms in Youth in The Netherlands. *JAMA Psychiatry*, 80(5), 451–458. <https://doi.org/10.1001/jamapsychiatry.2023.0294>
- Salzer, M. S., Brusilovskiy, E., & Townley, G. (2018). National estimates of recovery-remission from serious mental illness. *Psychiatric Services*, 69(5), 523–528. <https://doi.org/10.1176/appi.ps.201700401>
- Sonstroem, R. J., & Morgan, W. P. (1989). Exercise and self-esteem rationale and model. *Medicine & Science in Sports & Exercise*, 21(3), 329–337.
- Stubbs, B., Vancampfort, D., Hallgren, M., Firth, J., Veronese, N., Solmi, M., Brand, S., Cordes, J., Malchow, B., Gerber, M., Schmitt, A., Correll, C. U., De Hert, M., Gaughran, F., Schneider, F., Kinnafick, F., Falkai, P., Möller, H. J., & Kahl, K. G. (2018). EPA guidance on physical activity as a treatment for severe mental illness: A meta-review of the evidence and position statement from the European psychiatric association (EPA), supported by the international organization of physical therapists in mental health (IOPTMH). *European Psychiatry*, 54, 124–144. <https://doi.org/10.1016/j.eurpsy.2018.07.004>
- Teasdale, S. B., Ward, P. B., Samaras, K., Firth, J., Stubbs, B., Tripodi, E., & Burrows, S. (2019). Dietary intake of people with severe mental illness: Systematic review and meta-analysis. *The British Journal of Psychiatry*, 214(5), 251–259. <https://doi.org/10.1192/bjp.2019.20>
- Walker, E. R., McGee, R. E., & Druss, B. G. (2015). Mortality in mental disorders and global disease burden Implications. *JAMA Psychiatry*, 72(4), 334–341. <https://doi.org/10.1001/jamapsychiatry.2014.2502>