Article

Physical activity barriers among adults with physical disabilities or chronic diseases during and after rehabilitation: the ReSpAct cohort study

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Abstract: Adults with physical disabilities or chronic diseases face numerous barriers to participate in physical activity (PA). There is little knowledge about how these PA barriers evolve during and after rehabilitation, and how this relates to PA behaviour. In this study, we investigated how perceived PA barriers change over time for adults with physical disabilities or chronic diseases during and after rehabilitation, and their associations with PA behaviour. A total of 1,065 individuals from the longitudinal cohort study Rehabilitation, Sports, and Active Lifestyle (ReSpAct) were examined at various time points from baseline to 52 weeks post-rehabilitation. All participants received counselling as part of a PA promotion program in Dutch rehabilitation care. Longitudinal mixed model analyses showed that the frequency of perceived PA barriers decreased significantly during the transition from rehabilitation to community-based PA. These barriers, categorized as capability, opportunity, and motivation, were also found to be longitudinally negatively associated with self-reported total PA minutes per week. This study provides new insights into the dynamic nature of PA barriers for this diverse population and demonstrates how various types of PA barriers are related to PA behaviour. These findings offer valuable considerations for optimizing PA promotion strategies during and after rehabilitation.

Keywords: behaviour change; health promotion; longitudinal mixed model analyses

Introduction

People with physical disabilities or chronic diseases gain many physical and mental health benefits from regular physical activity (PA), leading to a reduced rate of mortality and improved quality of life (Durstine et al., 2000; Martin Ginis et al., 2021; Martin, 2013). Regular PA can decrease the risk of secondary health problems, reduce disability or disease-related complications, and improve daily functioning (Durstine et al., 2000; Martin, 2013). Nevertheless, research showed that PA levels are lower in people with physical disabilities or chronic diseases compared to the general population (Carroll et al., 2014; de Hollander & Proper, 2018; van den Berg-Emons et al., 2010). Moreover, people with disabilities are estimated to be 16 – 62% less likely than the general population to meet the 2010 World Health Organization (WHO) PA guidelines (Martin Ginis et al., 2021).

The generally low PA levels could be related to the many barriers that withhold people with physical disabilities or chronic diseases from engaging in PA (Martin Ginis et al., 2016;

Martin, 2013). Frequently mentioned PA barriers include pain, fatigue, and lack of time, motivation, or accessibility of gyms or equipment (Boutevillain et al., 2017; Rimmer et al., 2004; Vader et al., 2021). Behaviour change theories and models can enhance our understanding of how PA barriers influence PA behaviour (Lawrason et al., 2020; Ma & Martin Ginis, 2018). A simple-structured and commonly used model in PA research is the Capability, Opportunity, Motivation and Behaviour (COM-B) model (Michie et al., 2011). The COM-B model is developed by evaluating several frameworks of behaviour change interventions and overcoming the identified limitations, resulting in a theory- and evidence-based tool that is characterized by its simplicity. According to the COM-B model, the performance of a certain behaviour, in this case PA behaviour, depends on a person's Capability (i.e., physical and psychological ability), Opportunity (i.e., physical and social environment), and Motivation (i.e., reflective or automatic mental processes that influence behaviour) (Michie et al., 2011). By classifying PA barriers using the COM-B model, the nature of PA barriers and their effect on PA behaviour can be better understood.

While considerable research has been done to understand what types of PA barriers people living with physical disabilities or chronic diseases perceive (Martin Ginis et al., 2016), little is known about how these barriers change over time. Due to contextual changes, it is likely that barriers are dynamic. Indeed, Dinwoodie et al. (2022) found that frequencies of perceived PA barriers can change and decrease during a 9-week counselling intervention in people with chronic spinal cord injury (Dinwoodie et al., 2022). However, these findings are disability-specific and measured over a short period in a small sample (n=14). Moreover, an examination of the relationship between changes in PA barriers and PA behaviour is still lacking.

An important timeframe to promote PA in people with disabilities is during the final phase of rehabilitation and the initial period after rehabilitation (Rimmer, 2012). In the transition from rehabilitation-based activities to community-based activities, perceived PA barriers may likely change due to the many contextual changes that occur during this period. Examples of contextual changes are changes in living situation (inpatient vs outpatient) and exercise setting (rehabilitation vs community). The multicentred longitudinal cohort study "Rehabilitation, Sports and Active lifestyle" (ReSpAct) offers a unique opportunity to examine potential changes in perceived PA barriers and their relation with PA behaviour during this transition in a large group of adults with physical disabilities or chronic diseases (Alingh et al., 2015; Hoekstra et al., 2014). ReSpAct was initiated to evaluate the PA and sports stimulation program "Rehabilitation, Sports and Exercise" (RSE; Dutch: "Revalidatie, Sport en Bewegen"; Alingh et al., 2015; Hoekstra et al., 2014; Hoekstra et al., 2017). The RSE program was systematically and successfully implemented in 18 rehabilitation institutions (twelve rehabilitation centres and six hospitals) across the Netherlands (Hoekstra et al., 2021). The RSE program includes numerous counselling sessions utilizing motivational interviewing techniques, provided during and after rehabilitation, and aimed at promoting an active lifestyle. Counselling is a promising approach to help overcome PA barriers and improve PA behaviour in people with disabilities (Leidy et al., 2014; Morris et al., 2014; van der Ploeg et al., 2008; van der Ploeg et al., 2006).

In this study, we aimed to: 1) examine longitudinal changes in frequencies of PA barriers perceived by adults with physical disabilities or chronic diseases during and after the transition from rehabilitation- to community-based PA; 2) explore associations between perceived PA barriers and self-reported PA behaviour over time. We hypothesized that frequencies of perceived PA barriers decrease after discharge from rehabilitation, and that the greatest decrease would occur during the transition from rehabilitation- to community-based PA, since our study population received tailored PA counselling during this time period. Furthermore, we hypothesized that a decrease in frequencies of perceived PA barriers over time is associated with an increase in self-reported PA-behaviour.

Materials and Methods

Study overview

This study is part of the ReSpAct cohort study. Participants in the ReSpAct study engaged in the RSE program, in which they were offered multiple counselling sessions with a PA counsellor starting 3 – 6 weeks before discharge and ending at 13 weeks post-discharge from rehabilitation (Alingh et al., 2015; Hoekstra et al., 2014). Participants were recruited between May 2013 and August 2015 and were requested to complete a series of questionnaires at different time points: baseline (T0, 3 – 6 weeks before discharge), and at 14 (T1), 33 (T2), and 52 (T3) weeks post-discharge from rehabilitation (Alingh et al., 2015). The study received approval from the Ethical Committee of the Center for Human Movement Sciences of the University Medical Center Groningen (reference: ECB/2013.02.28_1). All participants participated voluntarily and provided signed informed consent.

Study population

Criteria for inclusion in the ReSpAct study were: (1) being 18 years of age or older; (2) having a physical disability or chronic disease; (3) undergoing inpatient, outpatient, or consultation rehabilitation within one of the participating rehabilitation institutions; and (4) involvement in the RSE program. Participants were excluded if they (1) were not able to complete the questionnaires, even with help, and (2) were participating in a PA stimulation program other than RSE.

For this study, we selected data from the ReSpAct cohort of adults who had (1) complete and valid responses on the barriers questionnaire at baseline (T0) and at least one follow-up assessment; and (2) complete and valid responses on the adapted version of the Short Questionnaire to Assess Health enhancing PA (Adapted-SQUASH) at baseline (T0) and at least one follow-up assessment.

Measures

Participant and rehabilitation characteristics

Participant characteristics comprised age, sex, body mass index (BMI), smoking habits, alcohol usage, education level, and employment status. Current smoking habits and alcohol usage were dichotomized into smoker/non-smoker and user/non-user. Education level was categorized into two groups for international comparability: high (applied university and above) and low. Employment status was categorized into school, employed, unemployed, retired, unable to work, and other (e.g., voluntary work). Participant characteristics were self-reported at baseline, except for age and sex, which were reported by the RSE counsellor.

Rehabilitation characteristics included the diagnosis, the context of rehabilitation (whether in a hospital or rehabilitation centre), the form of rehabilitation (inpatient, outpatient, or consultancy), and the number of follow-up counselling sessions that patients received as part of the RSE program (none, 1-3 sessions, or 4 or more sessions). We categorized diagnoses based on the Tenth Revision of the International Classification of Diseases and Related Health Problems (ICD-10) structure into; amputation (upper or lower extremities), brain disease (e.g., stroke), chronic pain, musculoskeletal disease (e.g., conditions of the upper and lower extremities and spine), neurological disease (e.g., Parkinson's disease, multiple sclerosis), organ disease (e.g., heart disease), spinal cord injury, and other conditions (e.g., chronic fatigue syndrome, medically unexplained symptoms) (WHO, 2004). The RSE counsellor reported the rehabilitation characteristics.

Physical activity barriers

A total of ten perceived PA barriers were measured, of which seven PA barriers were selected from the questionnaire used by Van der Ploeg et al. (2008) and the remaining three barriers were added by the ReSpAct research team based on expertise and previous literature (Alingh et al., 2015; Sallis et al., 1989; van der Ploeg et al., 2008). See Table 1 for the ten PA barriers and their corresponding PA barrier group and source. The frequencies of the perceived PA barriers were assessed by asking how often a certain factor hindered the participant from being regularly physically active, which included being physically active at least five days per week for a minimum of 30 minutes at a moderate to vigorous intensity. All perceived PA barriers were scored on a five-point Likert-type scale (never, rarely, sometimes, often, very often). To identify the type of barriers that influence PA behaviour, we thematically categorized the perceived PA barriers in three PA barrier groups using the COM-B model (i.e., PA capability, opportunity, and motivation barriers) (Michie et al., 2011). The mean scores for each barrier group were calculated. Data on PA barriers of a measurement occasion were deemed valid and complete when no PA barrier item scores were missing and all PA barrier items were scored between 1 and 5.

Physical activity behaviour

PA behaviour was assessed with the Adapted-SQUASH (Seves, Hoekstra, Schoenmakers, et al., 2021). The Adapted-SQUASH is a 19-item self-reported recall questionnaire, assessing the total minutes of PA in patient populations based on an average week in the past month. It has shown appropriate reliability and comparable validity to other PA questionnaires, when compared to accelerometer-derived PA (ICC = .76 for reliability, ICC = .22 for validity) (Seves, Hoekstra, Schoenmakers, et al., 2021). Participants reported the frequency, duration, and perceived intensity (light, moderate, or vigorous) of various types of activities structured into different settings in the questionnaire. These settings included activities during commuting, activities at work and school, household activities, and leisure time activities. Minutes of PA per week were calculated by multiplying frequency by duration. Total minutes of PA per week included light, moderate, and vigorous PA, while moderate to vigorous PA (MVPA) was calculated by summing the total minutes of moderate PA per week and the total minutes of vigorous PA per week. Same processes as in previous ReSpAct-studies were used to determine valid data on PA behaviour of a measurement occasion. Data from the Adapted-SQUASH were considered valid if no more than one of the predefined activity settings was missing, and the total weekly PA did not exceed 6,720 minutes (an average of 16 hours per day) (Brandenbarg et al., 2022; Brandenbarg et al., 2023).

Statistical analysis

Data analysis was performed using SPSS statistics V.27, IBM (New York, US). Descriptives for participant and rehabilitation characteristics, PA barriers, and PA barrier groups are presented as mean (M) and standard deviation (SD) for continuous variables, and percentages for categorical variables. Descriptives for self-reported PA levels are shown in median (IQR) because of non-normally distributed data. The differences in participant and rehabilitation characteristics between included and excluded participants were tested with independent t-tests or chi-squared tests.

We applied separate longitudinal mixed model analyses to analyse the change of perceived PA barriers over time (models 1 – 3) and their associations with self-reported PA behaviour (models 4 – 6a and b). In these models, measurement occasion was a level-1 variable and participant was a level-2 variable, to correct for multiple measurements within a person (random intercept models; covariance structure: variance components). To analyse

Table 1. The ten barrier items and the corresponding PA barrier group and source

PA barrier item	PA barrier group	Source
The person's disability/disease[a]	Capability	Van der Ploeg et al. (2008)
The person's physical complaints	Capability	Added by ReSpAct team; Alingh et al. (2014)
Lack of energy	Capability	Van der Ploeg et al. (2008)
Lack of self-discipline	Capability	Added by ReSpAct team; Alingh et al. (2014)
Limited possibilities in person's environment	Opportunity	Van der Ploeg et al. (2008)
Lack of time	Opportunity	Van der Ploeg et al. (2008)
Lack of money	Opportunity	Van der Ploeg et al. (2008)
Transportation problems	Opportunity	Van der Ploeg et al. (2008)
Lack of motivation	Motivation	Van der Ploeg et al. (2008)
Embarrassment for disability/disease	Motivation	Added by ReSpAct team; Alingh et al. (2014)

Note. [a] In papers by Van der Ploeg et al. called "health conditions".

the change in the means of PA barrier groups over time, we created three separate models with the categorical variable measurement occasion as independent variable (reference category: T0) and capability barriers (model 1), opportunity barriers (model 2) and motivation barriers (model 3) as dependent variables. Pairwise comparisons with Bonferroni correction were performed to adjust for multiple comparisons. Cohen's d was calculated for effect sizes to interpret the magnitude of the observed effects, with benchmarks of 0.2 for small, 0.5 for medium, and 0.8 for large effect sizes. To analyse longitudinal associations between PA barrier groups (independent variables) and self-reported PA behaviour (dependent variable), we created six longitudinal mixed models. Models 4-6 analyse d, respectively, the longitudinal associations between capability barriers and PA behaviour, opportunity barriers and PA behaviour, and motivation barriers and PA behaviour. We analyse d the associations of the PA barrier groups with both total minutes of PA per week (model 4a, 5a, 6a) and minutes of MVPA per week (model 4b, 5b, 6b).

All models were corrected for sex, age, BMI, diagnosis, and rehabilitation context. These confounders were partially based on a previous ReSpAct study showing that sex, age, BMI, and diagnosis have significant associations with PA (Brandenbarg et al., 2022). Dutch rehabilitation centres often have more PA facilities than hospitals making it likely that rehabilitation context is associated with perceived PA barriers and PA levels. Random slopes (covariance structure: unstructured) were considered for each model by evaluating the goodness of model fit (-2 log likelihood). Missing values were not imputed, since longitudinal mixed models are robust against missing data (Twisk et al., 2013). Significance level was set at $p < .05$.

Results

Participant and rehabilitation characteristics

Baseline characteristics per measurement occasion of the included (n = 1,065) and excluded (n = 654) participants in this study are shown in Table 2. Mean age increased gradually over time, with T0 at 50.0 years (SD = 13.3), T1 at 50.2 years (SD = 13.4), T2 at 50.7 years (SD = 12.9), and T3 at 51.0 years (SD = 13.0). The mean age of the excluded group was 49.6 years (SD = 14.4). Differences in age between the included group (T0) and the excluded group were not statistically significant ($p = .078$). BMI remained stable across the time points, with T0 at 27.4 (SD = 8.9), T1 at 27.5 (SD = 9.3), T2 at 27.6 (SD = 9.8), and T3 at 27.5 (SD = 10.0). Comparisons between the included group (T0) and the excluded group (M = 27.4, SD = 6.2) also showed no statistically significant differences ($p = .680$). The most common diagnosis groups were brain disease (25.7%, n = 274), musculoskeletal disease (18.8%, n = 200), and chronic pain (15.7%, n = 167). Compared to the included participants, excluded participants are more often female (p = .041), less likely to be smokers (p = .015), less likely to have a high education level (p = .001), and received fewer follow-up counselling sessions (p < .001).

Table 2. Baseline descriptive statistics of included participants per measurement occasion (T0 - T3) and excluded participants at T0, with p-values for tests between participants at baseline and excluded participants

	T0 (N = 1,065)	T1 (N = 906)	T2 (N = 785)	T3 (N = 713)	Excluded (N = 654) [a]	p [c]
Sex (% male)	48.2	48.1	48.8	50.2	42.2*	.041
Diagnosis						.859
Brain disease	25.7	25.5	25.1	26.2	27.5	
Musculoskeletal disease	18.8	18.8	18.0	17.0	18.0	
Chronic pain	15.7	16.0	14.6	15.4	17.6	
Neurological pain	15.4	15.0	16.2	18.0	12.5	
Organ disease	11.5	12.0	12.1	11.2	11.6	
Amputation	4.5	4.5	5.0	4.8	4.4	
Spinal cord injury	3.2	2.9	3.1	2.7	3.7	
Other diseases	3.8	4.0	4.3	3.6	3.4	
Alcohol user						.149
Yes	37.3	38.3	38.2	37.9	22.6	
No	51.3	52.8	53.2	52.9	38.5	
Smoker						.015
Yes	16.0	15.9	15.7	15.4	14.5	
No	72.6	75.2	75.8	75.3	46.8	
Marital status						.050
Single	26.0	26.8	26.8	26.4	24.2	
Married/with partner	64.3	65.3	66.5	65.6	43.9	
Education level [b]						.001
Low	66.4	66.8	67.8	68.2	54.2	
High	23.6	25.1	25.4	23.7	13.8	
Employment status					*	.126
Student	1.8	1.8	1.3	1.8	1.8	
Employed	33.5	35.1	34.8	34.5	20.0	
Unemployed	11.5	11.5	11.2	11.5	10.3	
Retired	13.6	14.3	13.6	14.4	12.8	
Unable to work	22.1	21.9	22.2	21.6	16.4	
Other	8.0	7.7	9.7	8.1	6.3	
Rehabilitation context						.062
Rehabilitation centre	70.5	71.0	71.0	71.2	76.0	
Hospital	295	29.0	29.0	28.8	24.0	
Rehabilitation form						.226
Inpatient	2.5	2.2	2.4	2.0	3.9	
Outpatient	90.1	90.7	89.6	90.5	89.4	
Consultancy	7.3	7.1	8.0	7.6	6.7	
Number of follow-up counselling moments						<.001
% 0	10.9	10.3	10.2	10.0	19.0	
% 1-3	57.6	56.7	56.8	57.4	53.8	
% 4 or more	31.5	33.0	33.0	32.7	27.2	

Note. Data are presented in mean (SD) and percentages; BMI = Body Mass Index;. [a] Excluded participants are excluded at T0; [b] Education level dichotomized into high (applied university and higher) and low; [c] p-values for statistical differences between included and excluded participants based on independent t-tests for continuous variables and based on X^2 tests for categorical variables.

Longitudinal changes in perceived PA barriers

Table 3 shows the mean score per PA barrier group (i.e., PA capability, opportunity, and motivation barriers) and the score per barrier item at all four measurement occasions decreased at all follow-up measurement occasions (T1, T2, T3), compared to baseline (T0).

Table 3. PA barrier group scores, individual barrier items and PA levels

	T0 (N = 1065)		T1 (N = 906)		T2 (N = 785)		T3 (N = 713)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Capability [a]	3.0	(0.8)	2.9	(0.8)	2.9	(0.8)	2.9	(0.8)
The person's disability/disease	3.4	(1.1)	3.2	(1.1)	3.1	(1.2)	3.2	(1.2)
The person's physical complaints	3.3	(1.1)	3.1	(1.1)	3.1	(1.1)	3.1	(1.2)
Lack of energy	3.1	(1.1)	3.0	(1.1)	2.9	(1.1)	3.0	(1.1)
Lack of self-discipline	2.4	(1.0)	2.3	(1.0)	2.3	(1.0)	2.4	(1.0)
Opportunity [b]	2.2	(0.7)	2.1	(0.7)	2.1	(0.7)	2.1	(0.7)
Limited possibilities in person's environment	2.5	(1.2)	2.3	(1.1)	2.3	(1.1)	2.3	(1.2)
Lack of time	2.2	(1.0)	2.2	(0.9)	2.2	(0.9)	2.2	(1.0)
Lack of money	2.2	(1.3)	2.2	(1.3)	2.1	(1.2)	2.0	(1.2)
Transportation problems	1.8	(1.1)	1.7	(1.0)	1.7	(1.0)	1.8	(1.1)
Motivation [c]	2.1	(0.8)	2.0	(0.8)	2.0	(0.8)	2.0	(0.8)
Lack of motivation	2.4	(1.0)	2.4	(0.9)	2.4	(1.0)	2.4	(1.0)
Embarrassment for disability/disease	1.7	(1.0)	1.7	(1.0)	1.6	(1.0)	1.6	(0.9)
Total physical activity (min/week)	1530	(859 - 2431)	1838	(1065 - 2910)	1920	(1080 - 2900)	1770	(990 - 2775)
Moderate-vigorous physical activity (min/week)	300	(108 - 750)	420	(150 - 960)	420	(138 - 1050)	390	(120 - 960)

*Note***.** Data presented as mean (SD) score on a five-point Likert-type scale (never, rarely, sometimes, often, very often), except for physical activity levels which is presented as median (IQR) minutes per week; [a] mean of the mean scores of the four barrier items belonging to PA barrier group 'capability'; [b] mean of the mean scores of the four barrier items belonging to barrier group 'opportunity'; [c] mean of the mean scores of the two barrier items belonging to barrier group 'motivation'.

Table 4 presents differences in the means of PA barrier groups at T1, T2, and T3 compared to baseline, along with 95% confidence intervals, p-values, and Cohen's d effect sizes. Longitudinal mixed models showed that the means of PA capability barriers and PA motivation barriers significantly decreased at all follow-up measurement occasions (T1, T2, T3), compared to baseline (T0). No significant difference was found between the mean of the PA opportunity barriers at T3 and baseline (T0). Model fit values and crude models are presented in Appendix A, Table A1 and A3.

Longitudinal associations perceived PA barriers and self-reported PA behaviour

Table 5 shows the results of the longitudinal associations between PA barrier groups (capability, opportunity, and motivation), and self-reported minutes of PA per week (total PA and MVPA).

The corrected models showed a significant negative longitudinal association between each PA barrier group (i.e., PA capability, opportunity, and motivation barriers) and total minutes of PA per week. For PA capability barriers and PA motivation barriers, significant negative longitudinal associations with minutes of MVPA per week were found. No significant longitudinal association was found between PA opportunity barriers and minutes of MVPA per week. Model fit values and crude models are presented in Appendix A, Table A2 and A3.

Table 4. Change in means of PA barrier groups (i.e. capability, opportunity, motivation) at T1, T2 and T3, compared to baseline (T0), using pairwise comparisons from linear mixed models analyses

		T1 - T0 Mean Δ	LCI	UCI	p	d
Model 1	Capability barriers	-.167	-.225	-.108	< .001	.23
Model 2	Opportunity barriers	-.068	-.123	-.013	.009	.10
Model 3	Motivation barriers	-.067	-.127	-.008	.019	.09
		T2 - T0				
Model 1	Capability barriers	-.207	-.268	-.145	< .001	.28
Model 2	Opportunity barriers	-.078	-.136	-.021	.003	.12
Model 3	Motivation barriers	-.076	-.138	-.014	.010	.10
		T3 - T0				
Model 1	Capability barriers	-.141	-.204	-.077	< .001	.20
Model 2	Opportunity barriers	-.056	-.116	-.003	.071	.08
Model 3	Motivation barriers	-.086	-.150	-.022	.004	.12

*Note***.** The longitudinal mixed models were corrected for sex, age, body mass index, diagnosis and rehabilitation context. No random slopes were added since that resulted in non-converging (i.e. unreliable) models. Pairwise comparisons were corrected for multiple testing using Bonferroni corrections. Mean Δ = difference in mean compared to baseline; LCI = Lower 95%Confidence Interval; UCI = Upper 95% Confidence Interval; d = Cohen's d (0.2 = small effect, 0.5 = medium effect, 0.8 = large effect).

Table 5. Results of the longitudinal mixed model analyses between PA barrier groups and PA outcomes

		Self-reported total minutes of physical activity/week Coefficient	LCI	UCI	p
Model 4a	Capability barriers	-221	-286	-157	< .001
Model 5a	Opportunity barriers	-76	-146	-7	.032
Model 6a	Motivation barriers	-80	-140	-19	.010
		Self-reported minutes moderate to vigorous physical activity/week			
Model 4b	Capability barriers	-131	-173	-89	< .001
Model 5b	Opportunity barriers	-35	-76	6	.090
Model 6b	Motivation barriers	-43	-81	-4	.031

Note. The table presents the results of longitudinal mixed model analyses focusing on PA capability barriers (models 4a and 4b), PA opportunity barriers (models 5a and 5b), and PA motivation barriers (models 6a and 6b) using data from T0 to T3. The outcomes analyse d were (a) self-reported total minutes of physical activity per week and (b) self-reported minutes of MVPA per week. The longitudinal mixed models were corrected for sex, age, body mass index, diagnosis and rehabilitation context. Random slopes were added for 4a + b and 5a, to improve the model fit. LCI = Lower 95%Confidence Interval; UCI = Upper 95%Confidence Interval.

Discussion

This study provided new insights into how PA barriers perceived by a large, heterogeneous group of adults living with physical disabilities or chronic diseases change over time during and after rehabilitation. Aligning with our hypotheses, we found perceived PA barriers significantly decreased during and after rehabilitation. PA capability barriers (e.g., health conditions, lack of energy) and motivation barriers (i.e., lack of motivation, embarrassment) were negatively associated with both total minutes of PA and MVPA. PA opportunity barriers (e.g. lack of possibilities, transportation problems) showed a significant negative association with total minutes of PA.

PA barriers during and after rehabilitation

The results showed that perceived PA barriers decreased slightly at all follow-up measurements compared to baseline. The largest decrease was found during the transition from rehabilitation- to community-based PA (T0-T1). Usually, PA barriers increase during the transition from rehabilitation to community (Martin Ginis et al., 2016; Rimmer, 2012). Therefore, it is reassuring that, in line with our hypothesis, the PA barriers actually decreased in our study, which we expect is a consequence of tailored PA counselling . Our results are in line with findings of Dinwoodie et al. (2022) showing that the number of PA barriers perceived by individuals with spinal cord injury can decrease over the course of a tailored counselling program. The study of Van der Ploeg et al. (2006) also showed

counselling increases PA behaviour and later identified the perception of PA barriers as an important underlying mechanism (van der Ploeg et al., 2008). Despite the significant changes in perceived PA barriers over time in our study population, it is questionable how meaningful these small changes are. Effect sizes (Cohen's d) indicated small magnitudes, suggesting that while statistically significant, the practical impact of these changes may be modest. Since the minimal important change for the PA barrier scores is unknown, the results may be influenced by the large sample size. However, small effect sizes are common in behavioural research, as demonstrated by a similar study that found associations between intrinsic motivation, identified regulation, self-efficacy, and the initiation and maintenance of PA behaviour (Brandenbarg et al., 2023). The effect sizes in our study are consistent with these typical findings in behavioural research. Nevertheless, our findings confirm that PA barriers are dynamic and have the potential to decrease over time. This study emphasizes the importance of measuring the dynamics of PA barriers and offer insights for future interventions aiming at decreasing perceived PA barriers.

However, the PA barriers tend to stabilize after the first follow-up measurement and do not decrease any further. This stabilization might be explained by our finding that, on average, participants in this study do not frequently perceive PA barriers during and after rehabilitation. Consequently, the frequencies of PA barriers cannot be decreased much more. Our results showed that PA opportunity and motivation barriers rarely (score of 2) and capability barriers sometimes (score of 3) hinder participants from being regularly active. These results are in contrast to a review of reviews emphasizing the frequent and considerable presence of PA barriers in people with disabilities or chronic diseases (Martin Ginis et al., 2016). Our findings are similar to the results of Van der Ploeg et al. (2008) including a comparable Dutch study population. The low PA barriers scores in both studies may be explained by the organization of the Dutch rehabilitation care. Since 1997, several rehabilitation centres started working together to integrate PA into rehabilitation care, which eventually led to the nationwide implementation of the RSE program (Hoekstra et al., 2017). Consequently, participants in our study were already supported in finding opportunities and gaining motivation to engage in PA during rehabilitation, through counselling and incentives, which might have resulted in the relatively low PA barrier scores. As a result, the observed small decreases in PA barriers after rehabilitation may be due to the fact that participants already perceived minimal barriers to PA participation. These findings may illustrate the value of integrating PA opportunities and PA promotion strategies in rehabilitation care.

PA barriers and self-reported PA behaviour

This study showed a significant negative longitudinal association between perceived PA capability and PA behaviour, indicating a decrease in frequencies of perceived PA capability barriers over time is associated with increase in PA behaviour. This means the total minutes of PA per week increases on average by 221 minutes (between T0 and T3), when the barrier score decreases by one point (between T0 and T3). This finding can be explained by the early post-rehabilitation phase that the participants were in. It is plausible that in the initial phase after discharge, participants still suffer from capability problems, such as pain, fatigue or other health conditions, that hinder them from engaging in PA. This is in line with the results of Van der Ploeg et al. (2008) who identified capability barriers 'health conditions' and 'lack of energy' as determinants of PA in a similar study population. A previous ReSpAct study showed that perceived fatigue is negatively associated with self-reported PA during and after rehabilitation (Seves, Hoekstra, Hoekstra, et al., 2021). From our results and previous literature (Seves, Hoekstra, Hoekstra, et al., 2021; van der Ploeg et al., 2008), it can be presumed that PA capability barriers, in particular lack of energy, have a large influence on PA behaviour (Total min PA: β=-221; MVPA: β=-131). Research showed that activity pacing is a promising tool to improve PA levels in people with chronic diseases who perceive fatigue, without exacerbating or even reducing fatigue symptoms (Abonie & Hettinga, 2021; Abonie, Sandercock, et al., 2020). Future research is needed to better understand how these PA capability barriers (i.e., lack of energy, fatigue) can be managed and reduced during and after rehabilitation by using activity pacing techniques in tailored (counselling) interventions (Abonie, Edwards, et al., 2020). Researchers have shown that activity pacing – defined as dividing daily activities into smaller, more manageable portions to prevent exacerbation of fatigue symptoms (Antcliff et al., 2015; Abonie, Edwards, et al., 2020) – is a promising tool to improve PA levels in people with chronic diseases who perceive fatigue (Barakou et al., 2023). This strategy often helps without worsening or even reducing these symptoms (Abonie & Hettinga, 2021; Abonie, Sandercock, et al., 2020). Future research is needed to better understand how these PA capability barriers (i.e., lack of energy, fatigue) can be managed and reduced during and rehabilitation by using activity pacing techniques in tailored (counselling) interventions (Abonie, Edwards, et al., 2020).

PA motivation barriers were significantly negatively longitudinally associated with both total PA and MVPA, and opportunity barriers showed a significant negative longitudinal association with total PA. These results are consistent with previous research identifying several PA opportunity barriers, such as limited opportunities in the environment, transportation problems, and financial costs, as determinants of PA in individuals with physical disabilities or chronic diseases (Martin Ginis et al., 2016; van der Ploeg et al., 2008). Additionally, studies have reported that autonomous motivation is associated with adherence to PA in the general population (Thøgersen-Ntoumani & Ntoumanis, 2006) and with increased PA in people with physical disabilities (Saebu et al., 2013). In contrast with PA capability barriers, the longitudinal association between PA opportunity barriers and total PA is smaller (β = -76 vs β = -221) and PA opportunity barriers do not show any significant association with MVPA. Similar to opportunity barriers, PA motivation barriers showed smaller longitudinal associations with PA behaviour compared to capability barriers (total PA: β = -80 vs β = -221; MVPA: β = -43 vs β = -131). These smaller longitudinal associations could be explained by the characteristics of this specific study-cohort. First, the ReSpAct cohort rarely perceived PA opportunity or motivation barriers. This might be due to the infrastructure in the Netherlands, where PA facilities and opportunities are often within a short distance. The ReSpAct cohort is known as a highly motivated study population (Brandenbarg et al., 2023). Second, the self-reported PA levels in this cohort are very high compared to other literature (Brandenbarg et al., 2022; de Hollander & Proper, 2018). The overall high PA levels over time can indicate that despite participants perceiving PA opportunity or motivation barriers, these may not have prevented them from being physically active.

Implications and future directions

Our findings enrich the existing PA literature by highlighting the dynamic nature of perceived PA barriers during and after rehabilitation and how they are related to PA behaviour. Using the COM-B model, we systematically collected and reported on changes in perceived barriers among a large, heterogenous group of adults with physical disabilities or chronic diseases that participated in a PA promotion program, and linked the findings to PA outcomes. While the observed changes in PA barriers were modest, our study highlights their variability over time, which is crucial for understanding the effectiveness of PA counselling interventions like the RSE program in enhancing PA levels among this population. Moving forward, these insights can inform future research exploring how and when PA counselling interventions, like the RSE program, may effectively improve PA levels among adults with physical disabilities or chronic diseases. Furthermore, these insights can be used by intervention developers, counsellors and researchers to further optimize PA promotion interventions. For example, if counsellors are more aware of the dynamics of perceived PA barriers during and after rehabilitation, this may result in improved barrier identification and problem-solving techniques, and subsequently may result in improved PA behavioural outcomes. To further advance our understanding of the dynamics of PA barriers and how this relates to PA behaviour, future research should investigate how barriers are identified and addressed throughout a counselling program. Analyzing counselling sessions using reliable coding methods (Dinwoodie et al., 2022; Michie et al., 2013) may help to identify optimal behaviour change techniques to address the various PA barriers that adults with physical disabilities or chronic diseases perceive during and after rehabilitation.

Strengths and limitations

A strength of this study is that the analyses were conducted in a large, heterogeneous group (n > 1,000) of adults with physical disabilities or chronic diseases who received rehabilitation treatment in different rehabilitation centres and hospitals, which improved generalizability of the results. Also, we analyse d longitudinal data collected during the important period of transitioning from rehabilitation- to community-based PA, to examine associations between PA barriers and PA behaviour. Finally, we used a simple-structured theoretical model (COM-B), that has been widely used in PA research. The classification of the PA barriers by COM-B makes the results easy to interpret. Using COM-B as our theoretical model makes our study comparable to other literature.

Besides these strengths, this study also has some limitations that need to be acknowledged. Our study population included participants with a variety of diagnoses. Results may differ between different diagnosis groups. Not all diagnostic groups were adequately represented in our dataset, with some groups potentially being underpowered. The differences in sample sizes across groups can influence the reliability of comparisons. For these reasons, we decided not to test for effect modification based on diagnosis. Another limitation pertains to the questionnaire used to assess the perceived PA barriers, which was not constructed based on the COM-B model. This questionnaire only gives a certain and limited impression of all kinds of PA capability, opportunity, and motivation barriers that can be perceived by adults living with physical disabilities or chronic diseases. For example, a psychological capability such as self-regulation and two forms of motivation (i.e., automatic and reflective motivation) are important factors that influence (PA) behaviour (Deci & Ryan, 2013; Michie et al., 2011) but were either not included or were insufficiently specific in our questionnaire. Several questionnaires have been developed that have shown validity in assessing perceived PA barriers in people living with disabilities, which might be a better choice for future research on PA barriers in this study population (Drigny et al., 2019). Furthermore, the ReSpAct cohort is a selective study group with a very high PA level compared to previous literature. First, this might be the result of measuring PA with a self-reported questionnaire, which can lead to overestimation of PA due to recall bias and social desirability (Nigg et al., 2020; Seves, Hoekstra, Schoenmakers, et al., 2021). Second, this might indicate that the ReSpAct cohort consisted of highly motivated adults who benefited the most from rehabilitation, which makes it difficult to generalize these results to a less active group of adults with physical disabilities or chronic diseases. Finally, the ReSpAct cohort participated in a specific intervention, the PA promotion RSE program, which included tailored counselling. Therefore, the results should be generalized with caution to adults living with physical disabilities or chronic diseases that did not participate in a similar PA promotion program as the RSE program.

Conclusion

Perceived PA barriers are dynamic and show small decreases over time among adults with physical disabilities or chronic diseases after participating in a PA promotion program. The relatively low PA barrier scores illustrate the potential value of integrating PA counselling during and after rehabilitation. All PA barrier groups (capability, opportunity, motivation) have shown a longitudinal association with PA behaviour. The findings demonstrate the importance of understanding the dynamics and nature of perceived PA barriers in relation to PA behaviours, to improve PA promotion strategies during and after rehabilitation.

Perspectives

This study contributes to existing research by revealing the dynamic nature of PA barriers, and showing these PA barriers can decrease, albeit modestly, during the transition from rehabilitation to community-based PA. Since the participants participated in a PA promotion program in Dutch rehabilitation care, it remains uncertain whether changes resulted from contextual factors or from the received counselling. Nevertheless, given that our participants experienced relatively few PA barriers, these observed dynamics offer a fresh perspective on the potential timing of effective PA promotion interventions. Previous literature would expect the PA barriers to increase in the transition from rehabilitation to community-based PA (Martin Ginis et al., 2016; Rimmer, 2012). This study underscores the importance of recognizing the evolving nature of barriers, emphasizing the significance of interventions during the critical rehabilitation-to-community transition. Understanding how changes in different types of PA barriers influence PA behaviour helps healthcare professionals tailor interventions effectively. This insight encourages collaboration between patients and healthcare providers, fostering strategies to overcome specific barriers and enhancing overall health and well-being. As such, this research provides a nuanced understanding of the dynamics of PA barriers and their association with PA behaviour, contributing to the refinement of targeted interventions in adapted physical activity.

Supplementary Materials: See Appendix section. Statistical codes for the longitudinal mixed model analyses are available on Open Science Framework: https://osf.io/n5t9s/

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Appendix

Table A1. Change in means of PA barrier groups (i.e. capability, opportunity, motivation) at T1, T2 and T3, compared to baseline (T0) (Crude models)

	T1 - T0				T2 - T0				T3 - T0			
	Mean Δ	LCI	UCI	p	Mean Δ	LCI	UCI	p	Mean Δ	LCI	UCI	p
Model 1 Capability barriers	-.161	-.217	-.104	< .001	-.202	-.261	-.143	< .001	-.139	-.200	-.078	< .001
Model 2 Opportunity barriers	-.068	-.119	-.016	.005	-.075	-.129	-.021	.003	-.061	-.117	-.006	.026
Model 3 Motivation barriers	-.052	-.109	.005	.086	-.061	-.120	-.002	.042	-.085	-.146	-.024	.003

Note. Crude models were not corrected for sex, age, body mass index, diagnosis or rehabilitation context. Mean Δ = difference in mean; LCI = Lower 95%Confidence Interval; UCI = Upper 95%Confidence Interval.

Table A2. Results of the crude longitudinal mixed model analyses between physical activity barrier groups and physical activity outcomes

	Self-reported total minutes of physical activity/week			
	Coefficient	LCI	UCI	p
Model 4a Capability barriers	-200	-255	-146	< .001
Model 5a Opportunity barriers	-53	-114	8	.087
Model 6a Motivation barriers	-74	-131	-17	.011
	Self-reported minutes moderate to vigorous physical activity/week			
Model 4b Capability barriers	-142	-177	-107	< .001
Model 5b Opportunity barriers	-56	-95	-17	.005
Model 6b Motivation barriers	-57	-94	-20	.002

Note. The table presents the results of crude longitudinal mixed model analyses focusing on PA capability barriers (models 4a and 4b), PA opportunity barriers (models 5a and 5b), and PA motivation barriers (models 6a and 6b) using data from T0 to T3. The outcomes analyzed were (a) self-reported total minutes of physical activity per week and (b) self-reported minutes of MVPA per week. Crude models were not corrected for sex, age, body mass index, diagnosis or rehabilitation context. LCI = Lower 95%Confidence Interval; UCI = Upper 95%Confidence Interval.

Table A3. Model of fit values (non-corrected, corrected and corrected with random slope) for each linear mixed model

	2-loglikelihood		
	Non-corrected	Corrected	Corrected with random slope
Model 1	7335.330	6206.367	6112.732*
Model 2	6680.156	5774.186	5716.612*
Model 3	7177.581	6142.727	6088.901*
Model 4a	59816.023	52217.192	52198.794
Model 5a	59872.453	52261.641	52245.611
Model 6a	59868.936	52259.856	52257.929
Model 4b	56696.792	49490.250	49440.140
Model 5b	56750.478	49526.808	49504.391*
Model 6b	56749.082	49525.061	49567.594*

Note. Corrected models were corrected for sex, age, body mass index, diagnosis and rehabilitation context. Bold models were used, * non-converging models