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Quality of life and health among persons with severe physical disabilities after participation in Team Twin – a push-assisted recreational running programme: A 16-week pre- and post-study

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Abstract: There is limited research on the health benefits of recreational sports for adults with severe physical disabilities. The Danish Team Twin has introduced an inclusive push-assisted running activity that involves both people with and without disabilities running together using specially designed running chairs. This study aimed to determine if participation in this activity could improve quality of life (QoL) and physical, mental and social health outcomes. The study was conducted over 16 weeks, with one weekly push-assisted running session averaging 77 minutes each. A single-arm pre-post design was applied. Health outcomes and participation perception were collected through self-reporting questionnaires (QoL, bio-psycho-social health, and programme experiences) and clinical examinations (cardiometabolic markers and body composition). The data were analysed using general mixed models and descriptive statistics. Twenty-one individuals completed an average of 10 push-assisted running sessions over the study period. The results showed no statistically significant difference in the primary outcome of QoL ($p = .42$) or other health-related outcomes. However, participants perceived the programme positively and reported experiencing joy, social belonging, motivation, and engagement. In conclusion, while there was no association between participation in Team Twin and QoL and health outcomes, the reported outcomes generally resembled the background population at baseline and follow-up. Future research is warranted to investigate participants' experiences to identify aspects of participation-related health and well-being.

Keywords: inclusion; community-based; health promotion; programme evaluation

Introduction

Individuals with disabilities face increased risks of physical and mental health issues compared to the general population (Iezzoni, 2011; Jahnsen et al., 2004; Peterson et al., 2013; Stumbo et al., 2011). Participation in community-based leisure and recreational activities is crucial for improving their health and quality of life (QoL) (Khasnabis et al., 2010; Stumbo et al., 2011). However, severe physical disabilities and ageing often create barriers that limit their participation in everyday activities (Hammel et al., 2015), including recreational and sports activities (Jaarsma et al., 2014; Martin Ginis et al., 2016). Despite

these barriers and the sparse existing literature compared to research among the general population, tailored physical activity and exercise programmes have shown significant improvements in physical, mental and social health, as well as overall well-being, for individuals with disabilities, ultimately leading to an enhanced QoL (Aitchison et al., 2021; Diaz et al., 2019; Martin Ginis et al., 2021; Sahlin & Lexell, 2015). However, research often overlooks programmes for adults with the most severe physical disabilities, as most recreational sports interventions focus on children or adults who are able to participate independently (Klenk et al., 2019; Lai et al., 2021), leaving a gap in studying the impact of recreational sports on the physical, mental and social health and QoL of those with severe physical disabilities.

The Danish pre-existing recreation programme, 'The Team Twin – We Run Together', addresses the lack of community-based sports opportunities for individuals with severe physical disabilities. The programme provides weekly push-assisted running activities that involve volunteers with no physical disability. The programme aims to integrate disability sports with mainstream sports, fostering a communal spirit and improving health and QoL for all participants (Team Twin - We Run Together, 2020). Studies suggest that inclusive recreational programmes which bring together people with and without disabilities are beneficial for all participants, especially in the social domains, as feeling valued and accepted (Mayer & Anderson, 2014).

A preliminary non-peer-reviewed pilot study has been conducted among a small sample of people with severe physical disabilities who participated in the Team Twin programme. The study presented preliminary findings that indicated a potential improvement in physical health and activities of daily living, such as increased heart rate, improved sleep, functional mobility and social and mental health benefits such as belonging, identity development and equality (Winther et al., 2018).

Considering the major barriers to participation in leisure sports (Jaarsma et al., 2014; Martin Ginis et al., 2016) and the considerable void in community-based sports opportunities among this subpopulation (Duvall et al., 2021; Lai et al., 2021), a programme tailored to this group could potentially improve their physical, mental and social health. Despite that, a limited number of studies have explored the mental and social health benefits of participating in recreational sports with assistance from others or electrical aids (e.g. adapted skiing (Hague, 2023), power wheelchair football (Barfield et al., 2005; Jeffress & Brown, 2017)) . Additionally, these examples of assisted movement through others have indicated that their bodies are reacting to this physical exertion, suggesting that participation in these activities triggers certain physiological responses in these individuals (Barfield et al., 2016; Dirienzo et al., 2007; Hague, 2023; Selph et al., 2021). Hence, due to the significantly lower life expectancy, with respiratory disorders being a common cause of death (Strauss et al., 2008), exploring interventions to mitigate this risk is vital. Altogether, this sparse literature collectively suggests a potential for improving various aspects of health and QoL. Thus, further investigation of the potential for improved physical, mental and social health is vital, as people with most severe physical disabilities are more sedentary (Verschuren et al., 2016) and underrepresented in community-based sports activities (Klenk et al., 2019; Lai et al., 2021). Given the significant difficulties associated with being physically active for individuals with severe physical disabilities, physiological benefits are likely to occur at lower intensities, durations and frequencies than recommended, particularly among those highly deconditioned (Martin Ginis et al., 2021), as the case among this sample. Therefore, this study adopts the WHO concept of quality of life, distinguishing physical, mental and social health aspects (Harper et al., 1998). Subjective and objective assessments are used to evaluate participants' perceptions of their health, QoL, and potential physical

benefits from participating in the Team Twin programme, where others assist them in their movement

Thus, this study primarily aimed to investigate whether participation in the Team Twin programme would affect self-perception of QoL among people with severe physical disabilities. Secondarily, we explored changes in bio-psycho-social health outcomes and captured the participants' perceptions and experiences of the Team Twin programme. Finally, we investigated the potential of cardiometabolic impact after 16 weeks of the push-assisted running concept.

Materials and Methods

Study design, recruitment and participants

The study employed a 16-week single-arm pre/post design, with participants serving as their own controls. Eligibility criteria encompassed individuals aged >18, affiliated with a local Team Twin club and legally competent (i.e. having the ability to take care of their own interests). The Team Twin community facilitated the recruitment by inviting approximately 150 potential participants (handiathletes) through an information flyer developed by the research team. Interested handiathletes were contacted directly and provided with further information. Recruitment occurred from January to March 2021 and new Team Twin members were prioritised. However, experienced members (>1 year membership) were also included due to a low inclusion rate. The study, registered at Clinical Trials.gov (NCT04536779)), received approval from the Ethics Committee of the Capital Region of Denmark (Journal nr.: H-20010668), adhering to the Declaration of Helsinki standards. Participants received comprehensive information, followed by 24 hours for reflection before providing their consent. The detailed study protocol has been published elsewhere (Jørgensen et al., 2021)

Team Twin is a volunteer-driven sports community where volunteers with no physical disability (referred to as runners) assist those with severe physical disabilities in recreational push-assisted running using specialised running chairs. For more details about the equipment and the push-assisted running carried out in(Team Twin - We Run Together, 2020) practice, visit Assistive Technology Data – Denmark (2024) and the Team Twin webpage

The organisation comprises over 500 members, including 150 handiathletes and 350 runners across ten local clubs in Denmark (Team Twin - We Run Together, 2020). The handiathletes represent a diverse group with various severe physical disabilities (e.g. quadriplegia cerebral palsy).

The Team Twin programme operates with a standard curriculum of one weekly push-assisted running session every Sunday morning, covering approximately a 10-kilometer route. During the push-assisted sessions, runners and handiathletes are randomly paired up in minor teams and interact using both verbal and non-verbal communication, depending on the handiathletes' abilities. The teams of handiathletes and runners are formed based on the number of registered participants, with a minimum requirement of one runner and one handiathlete. Typically, two or three runners share the task of pushing the chair. After each push-assisted running session, a social gathering occurs and involves handiathletes, runners and relatives. The volunteers who engage in these push-assisted running sessions with the handiathletes are often recreational runners, family members, or caregivers. Team Twin also participates in official races like the Copenhagen half or full marathon. The programme offers an opportunity for individuals with and without disabilities to engage in recreational sports and promotes collaboration, socialisation and inclusivity, ultimately intending to improve the member's QoL (Team Twin - We Run Together, 2020). This study enrolled

members from six of Denmark's ten local Team Twin clubs, and sixteen push-assisted sessions were scheduled over the 16-week programme period, one per week.

Data collection and assessments

The handiathletes were asked to complete a web-based questionnaire before and after the 16-week programme to assess their self-reported health outcomes. The questionnaire covered aspects of QoL, psychosocial and physical health. The follow-up questionnaire included inquiries about the participants' experiences and perceptions of Team Twin. Prior to completing the questionnaire, fifteen handiathletes indicated they received supervision from relatives or caretakers throughout their completion.

The clinical examination baseline measures were scheduled twice, with approximately one month in between (pre1 in April and pre2 in June of 2021, with the Team Twin session on hiatus). The follow-up measurement was conducted in October 2021, after completing the 16-week programme period (from June to October). For most participants (n=17), an average of pre1 and pre2 was used as a combined baseline value. This was done to ensure stability and consistency in participants' baseline levels before the intervention. However, due to practical constraints—such as participants continuing attendance in Team Twin activities between pre1 and pre2 or enrolling after the pre1 examination—not all participants completed both pre1 and pre2 (n=4). For participants with only one clinical examination (either pre1 or pre2), that single measure was used as their baseline values. A flowchart of the is provided for details in Supplementary Figure 2.

We encountered significant challenges in implementing standard operating procedures within this population, which affected data quality (i.e. validity and repeatability). To address these issues, we used participants' first clinical examination as a procedure reference point to identify and implement necessary adjustments for the subsequent tests (pre2 and follow-up examinations). Hence, we tailored and adjusted the testing procedures to accommodate individual needs (e.g., adding sugar-free flavour to OGTT drink to avoid nausea).

All clinical examinations occurred at the Centre for Physical Activity Research, Rigshospitalet. To gain information about the programme's contextual demographics (e.g., duration, distance, and attending members), runners who attended the sessions completed a web-based trip registration questionnaire on their smartphone through a QR code immediately after the session; 34 sessions were recorded. The study design, data assessment, and data collection flow are illustrated in Supplementary Figure 1.

Quality of life

The primary outcome, QoL, was assessed by the 'Cantril Ladder of Life Scale', which ranges from 0 to 10 (Cantril, 1965). The higher the score, the better the perceived QoL. Cantril's Ladder has been used among various target groups, including people living with disabilities (Mesterman et al., 2010), and has demonstrated high reliability and validity (Levin & Currie, 2014).

Self-reported secondary bio-psycho-social health outcomes

Well-being was assessed by the WHO-5 Well-Being Index, with scores ranging from 0 to 100, with higher scores indicating better well-being (Bech, 2012; WHO, 2024). A ten-point change score post-intervention is considered clinically relevant (Ware et al., 1996).

Self-perceived health was assessed by asking participants, 'In general, would you say your health is?' (Ware et al., 1996). Their answers ranged from excellent to very poor on a five-item Likert scale. Answers were dichotomised into 'good' if excellent/very good/good were chosen, otherwise 'poor'.

General self-efficacy was assessed using a modified Danish two-question questionnaire (Nielsen, L. et al., 2012). Responses were measured on a 5-point Likert scale and then dichotomised into 'high self-efficacy' and 'low self-efficacy' categories.

Loneliness was assessed using the Danish version of the Three-Item Loneliness Scale (T-ILS), with scores ranging from 3-9 and dichotomised into 'not lonely' by 3–5 points and 'lonely' by 6–9 points. The T-ILS is recommended to be used among adults with disabilities by the Danish National Board of Social Services and has shown good reliability and validity (Nielsen, T. et al., 2021).

Sleep quality was measured on a 5-item Likert scale by asking the handiathletes how often they had experienced poor sleep quality during the previous month (Nordin et al., 2013). Answers were dichotomised into 'poor sleep quality' if 'often/always poor sleep quality' was chosen and 'good sleep quality' if 'sometimes/rarely/never poor sleep' was chosen.

Pain in the locomotive apparatus was measured using three Danish National Health Surveys questions covering pain perception in the shoulder and neck, lower and upper limbs and back and loin (Jensen et al., 2018). We gave the score 'high perceived pain' if the handiathletes answered 'Yes, great discomfort' to at least one of the three questions, whereas 'low(er) perceived pain' was the score if the answers were 'no or minor discomfort' to all three questions.

Cardiometabolic health and body composition

Markers of cardiometabolic health encompassed glycated haemoglobin (HbA1c), blood glucose concentration following a 2-hour oral glucose tolerance test (2-h OGTT), total cholesterol, high-density lipoproteins-cholesterol, low-density lipoproteins-cholesterol and office systolic – and diastolic blood pressure, core outcomes, considered by the expert in the field of the disability community, to measure within health research among people with disabilities (Benner et al., 2019). The OGTT drink was comprised of 83 g of dextrose diluted in 293 ml water. A peripheral venous catheter was placed in the antecubital fossa for blood sampling. All blood samples were analysed at the Department of Clinical Biochemistry, Rigshospitalet, Copenhagen, Denmark and were conducted by the same team, including the authors AJ, MPPL, GEL and MRL.

Estimates of body composition, including whole bone mineral density (BMD), whole body lean mass (kg) and fat per cent (%), were obtained using Dual X-ray absorptiometry (DXA) (Prodigy Advance, GE Medical Systems—Lunar, Madison, WI, USA). Office blood pressure was measured (calibrated Microlife BP A3 Plus blood pressure monitor Microlife AG Swiss CorporationEspenstrasse 139, CH-9443 Widnau/Switzerland) on the upper (less affected) arm and based on the average of three measurements obtained with five-minute intervals between each measurement.

Post-programme evaluation: Perception, experiences and values of participating in the Team Twin programme

During the follow-up questionnaires, we used the OVal-9 questionnaire (Persson & Erlandsson, 2010), which is based on the ValMO model (Value and Meaning in Occupations) developed by Persson and Erlandsson (2001). This theoretical framework assesses how individuals value various occupations, including recreational activities, within different settings. The ValMO model is a theoretical concept plays a crucial role in understanding the factors shaping the overall experience of meaningful occupation and, ultimately, life (Persson et al., 2001). The OVal-9 questionnaire gauges the valuation process, with participants rating their experience of nine specific values on a scale from 1 (low) to 7 (high) while engaged in the occupation by being asked, 'When I am engaged in this occupation, I…

(e.g., feel pleasure and/or satisfaction, relax)'. The OVal-9 questionnaire exhibits good content validity for evaluating the value experienced in activities during everyday life (Persson & Erlandsson, 2010). The full OVal-9 questionnaire is available from the original authors and the original publication (Persson & Erlandsson, 2010). To make it easier to interpret the responses, the OVal-9 questionnaire was adapted and categorised into three levels: low (1-3), non-aligned (4) and high (5-7) occupational values.

In addition, the participants responded to statements about their perceived experience and feelings regarding their participation in the Team Twin programme, which we had developed on a 5-point Likert scale. For example, they were asked to rate their motivation to participate in Team Twin. The responses were categorised as 'agree' 'neither nor', or 'disagree'. For the statement formulations, see Supplementary Table 1.

Sample size

The sample size calculation was based on estimates from a previous Danish study among people living with disabilities (Jespersen, 2018) using a standard SD of 1.0 and a 10% difference from baseline to follow-up in QoL as the minimal significant difference. Based on these estimates, 19 persons were estimated to obtain a statistical power of 80% (alpha=5% - two-sided) (Jørgensen et al., 2021)

Statistical analysis

Continuous outcomes (i.e. Cantril ladder, WHO-5, cardiometabolic markers and body composition estimates) were analysed using linear mixed models that account for the structure of the repeated measures and the correlated data. Differences were estimated as a mean change with 95% confidence intervals (95% CI) from the baseline to the 16-week follow-up (time), adjusted for age (continuous), sex (two levels) and baseline values (continuous). For participants with two clinical baseline examinations (n=17), the baseline was calculated as the mean of the two examinations (see Supplementary Figure 2: Flowchart). Self-perceived health, self-efficacy, T-ILS, pain and sleep quality were constructed as binary variables due to the small sample size, making some categories too small for statistical analysis. These were analysed using mixed logistic regression models and reported as odd ratios (OR) with 95% CI, adjusted for sex and age. Descriptive analysis was used for post-programme evaluation, capturing the participant's perceived experiences of the programme reported as percentages.

In a subgroup analysis, the primary outcome, QoL, was further stratified by experienced and new members and per protocol (defined as a threshold of a minimum of eight sessions) as pre-planned (Jørgensen et al., 2021). Linear mixed models were visually validated for Best Linear Unbiased Predictions, residuals and homoscedasticity (no violations of the assumptions were found). Due to the repeated mixed models, partly uncompleted cases will be included in the analysis despite dropout. Thus, missing data were not imputed, and all data were used despite partial completion (see Supplementary Figure 2: Flowchart). A two-sided test with a significance level of 0.05 was used. All analyses were conducted using STATA version 17 (StataCorp LP, College Station, TX, USA).

Results

Participants demographics and contextual programme factors

A total of 150 handiathletes were invited to participate in the study based on their involvement in a Team Twin club, and 22 individuals (15%) were enrolled in the study. The main reasons for not engaging in the study included no response to the invitation, no interest in the project, or inability to participate in the clinical examination due to geographical distance. Following inclusion, one handiathlete withdrew before entering baseline

measurements due to non-enrolment in a Team Twin club, and 21 were included in the analysis (see flowchart Supplementary Figure 2). As denoted in Table 1, handiathletes had a mean age of 33 (range 19 - 65y), distributed equally between men and women. Newly enrolled members counted for half of the sample (48%). Despite the other half of the sample comprising experienced handiathletes, 72 % of those had not participated in over six months due to COVID-19 (data not shown). The majority received financial subsidies; still, some handiathletes continued to participate in daily activities, including attendance at special schools or engagement in flexible employment. Three-quarters of the handiathletes were diagnosed with cerebral palsy. Of those with cerebral palsy, most had all four limbs affected and a Gross Motor Function Classification System level at IV-V. The remaining participants reported conditions such as multiple sclerosis, muscular dystrophy, developmental disability (i.e. physical, intellectual or both) and inherited neurodegenerative diseases (corresponding to *Other* in Table 1).

Throughout the study, runners from five out of the six clubs enrolled reported a total of 34 sessions through the QR-coded questionnaire. Data gave insights into the programme's demographics. Handiathletes participated on average in 10 (SD = 5.5) sessions. The average session duration was 77 minutes (SD = 24) and the mean distance covered was 10.5 kilometres (SD = 5.5). On average, seven (SD = 3.0) runners and four (SD = 2.0) handiathletes were present at each session across all Team Twin local clubs. In total, 70% (n= 14) of participants completed the minimum of eight pre-determined sessions (per protocol) divided equally among new and experienced members (n=7, respectively) (data not shown).

Table 1. Baseline demographics of the handiathletes (n = 21)

	n	%	Mean	SD
Age	21	-	33.6	12.5
Male	12	57	-	-
Female	9	43		
Occupation [a]				
Disability benefit, retirement, or pensioner	17	81	-	-
Other (flexi-job, education)	4	19	-	-
School (special) or in between education	5	24	-	-
Highest education				
Primary school	15	71	-	-
Secondary school or above	6	19	-	-
Disability type				
Cerebral palsy (GMFCS; III-V)	16	76	-	-
Other	5	24	-	-
Handiathlete Experience				
New member (never attended before)	10	48	-	-
Experienced member (>1 year)	11	52	-	-

Note: [a]Multiple choices available (sum more than 100%). Abbreviation: GMFCS = Gross Motor Function Classification System.

Quality of life

The mean QoL score changed by 0.3 points, from baseline to follow-up, which was not statistically significant (Table 2). The subsample analysis did not point to the effect being modified by level of experience (new vs. experienced members). However, the per protocol sample (adherence to minimum eight sessions during the 16 weeks) improved their perception of QoL marginal statistically significant from baseline to follow-up with 0.93 points (p= .050), pointing towards those who participate more frequently assess their perception of QoL to a higher degree (Supplementary Figure 3).

Psychosocial and physical health outcomes

The mean well-being score changed from baseline to follow-up by 3.9 and was not statistically significant. At follow-up, no change was observed in handiathletes feeling lonely or rating their self-perceived health differently from baseline. No change was observed in self-reported self-efficacy at follow-up compared to baseline. Moreover, no statistically significant change in the pain score at follow-up compared to baseline was observed. Neither did we see any difference in self-reported sleep quality at follow-up (Table 2). No improvement nor deterioration of significance was observed in the markers of cardiometabolic health or body composition (Table 3). The clinical biomarkers (glycaemic control, blood lipids, blood pressure) were generally within the normal range of physiological reference intervals at both baseline (mean of pre1 and pre2) and follow-up (Table 3). Subsample analysis stratified on per protocol and seniority did not demonstrate any significant difference (data not shown).

Table 2. Mixed linear and logistic regression analyses on handiathletes self-reported health outcomes at 16-week follow-up.

	Baseline (n=21)		Follow-up (n=20)					
Continuous variables[a]	Mean	SD	Mean	SD	MD	LCI	UCL	p
Quality of Life	6.8	2.0	7.1	1.6	0.3	-.48	1.4	.42
Well-being	61.3	20.3	65.1	18.5	3.9	-5.1	12.9	.40
Binary variables[b]	%		%		OR	LCI	UCL	p
Self-perceived health								
Poor	19		20		REF	-	-	-
Good	81		80		0.97	04	24	.99
Self-efficacy								
Low	57		30		REF	-	-	-
High	43		70		6.2	0.8	50	.08
Feeling loneliness								
Lonely	38		35		REF	-	-	-
Not lonely	62		65		1.2	0.3	5.5	.78
Pain								
Severe	52		25		REF	-	-	-
Minor to no pain	48		75		5.8	0.7	45	.09
Sleep quality								
Poor	33		20		REF	-	-	-
Good	67		80		2.5	0.4	16	.34

Note: [a]adjusted for sex, age and baseline values, [b]adjusted for sex and age. Abbreviations; SD = Standard Deviation, MD = Mean Difference, OR = Odds ratios, LCI = Lower 95% Confidence Interval, UCI = Upper 95% Confidence Interval.

Perception of the Team Twin programme

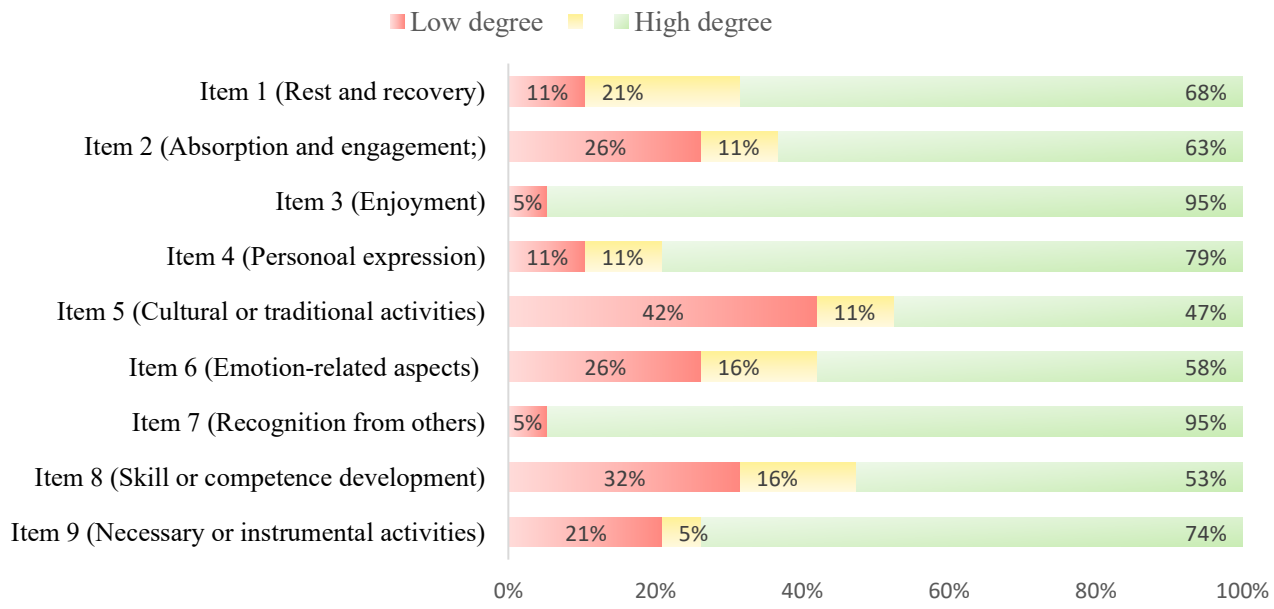
At follow-up, most handiathletes perceived high value from the Team Twin programme (Figure 1). The three most frequently reported perceptions were ‘Receiving appreciation’, ‘Feeling pleasure and satisfaction’ and ‘Expressing an important part of me’. Figure 2 outlines the participants’ perceptions and experiences during the study period as rated after the 16 weeks. Almost every statement received overall agreement. Notably, statements concerning the sense of togetherness (item 1), positive team experiences (item 2) and motivation to continue participating (items 3 and 4) garnered almost unanimous high agreement. Statements regarding transferring and understanding physical and social life skills and abilities to other life situations had the lowest agreement (items 9, 10 and 11).

Table 3. Mixed linear regression analyses on handiathletes clinical examination outcomes at 16-week follow-up.

	Baseline[a] (n=21)		Follow up (n=19)					
	Mean	SD	Mean	SD	MD [b]	LCI	UCL	p
Glycemic control								
HbA1c (mmol/mol)	31.9	2.8	32.2	3.5	0.2	-0.36	0.80	.45
2-h OGTT (mmol/l)*	6.9	1.8	6.7	1.7	-0.4	-1.00	0.13	.13
Blood lipids								
Total cholesterol	4.7	1.4	4.6	1.09	-0.06	-0.40	0.27	.73
HDL-C (mmol/l)	1.3	0.2	1.4	0.27	0.03	-0.01	0.09	.15
LDL-C (mmol/l)	2.9	1.2	2.9	1.02	-0.06	-0.35	0.22	.66
Blood pressure								
Systolic (mmHg)	120.0	18.8	119.8	24.7	-2.3	-6.8	2.14	.31
Diastolic (mmHg)	78.7	13.9	82.5	21.1	3.3	-2.53	9.18	.27
Body composition **								
Whole body lean mass (kg)	32.1	6.6	32.8	6.7	-0.08	-0.61	0.44	.77
Whole body fat percent (%)	35.6	13.9	38.6	12.7	0.1	-0.84	0.03	.84
Whole body BMD (g/cm2)	1.06	0.10	1.05	0.11	-0.01	-0.02	0.00	.08

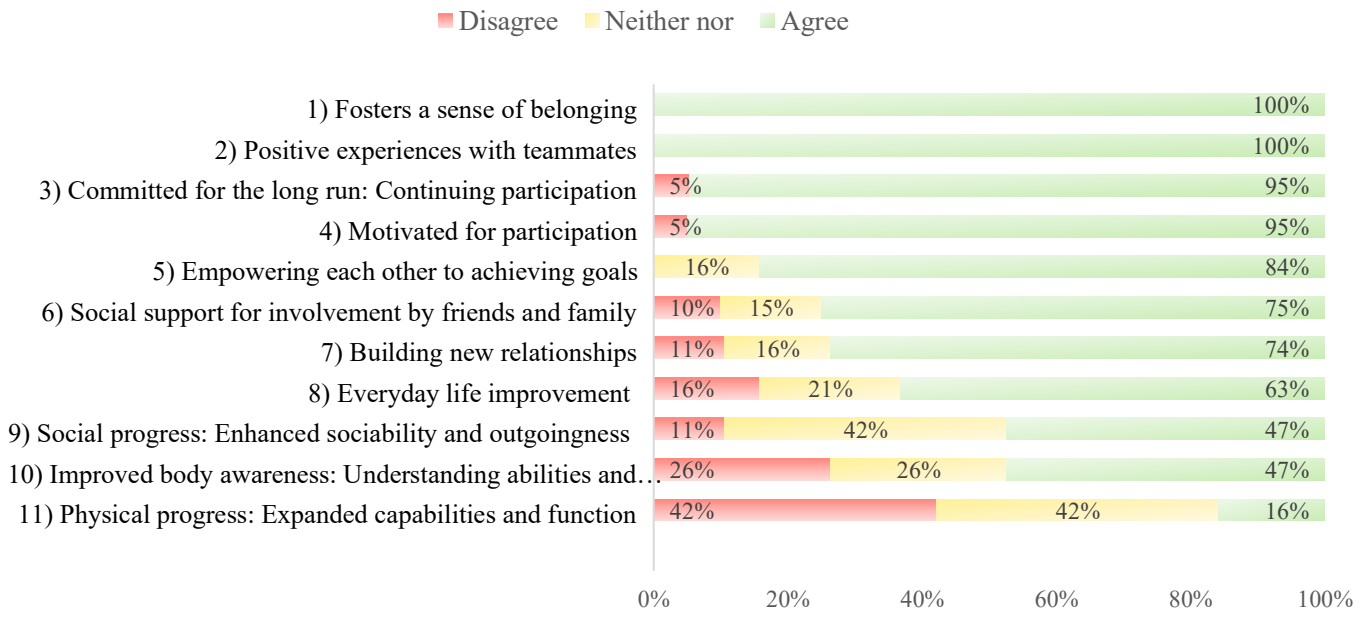
Note; [a]Mean of pre1 and pre2, [b]adjusted for sex, age and baseline values, *n=16 due to missing data, **n=19 due to missing data. Abbreviation; SD = Standard Deviation, MD = Mean Difference, LCI = Lower 95% Confidence Interval, UCI = Upper 95% Confidence Interval, GMFCS = Gross Motor Function Classification System, HbA1c = Glycated hemoglobin, 2-h OGTT = two-hour Oral Glucose Tolerance Test, HDL-C = High-Density Lipoproteins-cholesterol, LDL-C= Low-Density Lipoproteins-cholesterol, BMD = Bone Mineral Density.

Figure 1. Handiathletes' perceptions of the value and meaning of participation in the Team Twin programme (n=19)



Distribution of responses across OVal-9 items, based on the ValMO theoretical model, assessing perceived value and meaning in daily occupations (Erlandsson et al., 2011). Item numbers are shown with conceptual domain labels in brackets due to copyright restrictions; see Persson & Erlandsson for the full instrument and formulations (2010).

Figure 2. Perceived experiences from participation in the Team Twin programme (n=19)



Sorted by those statements with the highest agreement

Discussion

The aim of this study was to examine the impact of participation in the Team Twin programme on key health and psychosocial outcomes by combining objective health indicators with self-reported experiences. We observed no statistically significant improvements in QoL or other health indicators. The per protocol sample (minimum eight sessions of participation) was associated with marginally statistically significant improvement in QoL. Moreover, most participants reported that they regarded their participation in Team Twin as a highly valued activity, and they were eager to continue. The handiathletes felt a social bond, reached shared goals with peers and people without disabilities, and had positive experiences with their teammates.

The baseline levels for this sample were generally high, which is consistent with similarly positive self-reported well-being among people with disabilities, as reported by Colver and colleagues (2014). However, these results contrast with findings from other studies of the same population (Iezzoni, 2011). It is important to note that QoL and well-being may not necessarily be affected by a person's disability, which is why people with disabilities may indicate an average good self-perceived health and QoL (Albrecht & Devlieger, 1999). This distinction between living with a disability and reporting good health and QoL is consistent with findings in the Danish background population, where scores on comparable instruments were reported as 7.6 for QoL (Helliwell, 2022) and 68 for well-being (Danish Health Authority, 2017). Furthermore, the majority rated their self-perceived health as good, similar to findings in the Danish background population (Rosendahl et al., 2022). Additionally, a modest one-fourth of the participants reported poor sleep and severe pain at follow-up. This is substantially lower than reported in previous studies, where poor sleep affected approximately 75% of individuals (McPhee et al., 2020), and moderate to severe pain prevalence ranged from around 28% (Jahnsen et al., 2004) to 65.1% in pooled estimates (van Gorp et al., 2020). Furthermore, overall good health and well-being status could partly explain their perception of pain, as good mental health serves as a protective factor against pain (Santini et al., 2023) or vice versa.

We did not observe any improvements in cardiometabolic health and body composition. However, the mean of glycemic control, blood lipids and blood pressure lies within the

recommended range (eHealth – Danish Healthcare Services, 2022a, 2022b), making room for improvement difficult. Despite other recreational sports activities for people with disabilities, where being moved by others (e.g. electrical wheelchairs or mounted therapeutic riding) has been shown to induce an elevated heart rate that could affect the biomarkers of interest (Barfield et al., 2016; Dirienzo et al., 2007; Winther et al., 2018). The unaffected outcomes in cardiometabolic health and body composition should be seen in the light of the relatively short intervention period (16-week duration), and the format of 'exercise' (push-assisted running), dose (once a week) and mostly very light intensity (Jørgensen et al., 2023). Despite evidence suggest the potential for improvement at lower physical activity levels (Martin Ginis & West, 2020; Martin Ginis et al., 2021) than prescribed by WHO guidelines (150–300 min/week moderate or 75–150 min/week vigorous aerobic activity, or equivalent mix (Bull et al., 2020)), the Team Twin programme does not align with any lower physical activity recommendations for people with disabilities (e.g. (Martin Ginis & West, 2020; Verschuren et al., 2016)). Therefore, findings suggest that the Team Twin concept of being moved by others is insufficient to promote physical activity per se that would elicit cardiometabolic improvement or change in body composition. Furthermore, in the subjective assessment, the most disagreed statement was about a sense of 'physical progress', pointing towards the importance of social and mental well-being rather than physical health improvements – a focus previously suggested to be superior solely to the physical benefits of participation in intervention and sports programmes (Colver et al., 2014; Ives et al., 2021).

The initial QoL score was lower for the per protocol sample at baseline, potentially explaining the observed improvement in this subgroup. Research indicates that long-term participation, social support and team involvement are positively associated with recreational sports participation, potentially influencing QoL and well-being (Aitchison et al., 2021; Diaz et al., 2019; Labbé et al., 2019). Adherence typically refers to intervention compliance but may be insufficient for interventions like Team Twin, as the latest research in the field of adaptive sports points towards that participation quality is more important than attendance rate per se to improve QoL and well-being (Evans et al., 2018; Martin Ginis et al., 2024). During the 16-week Team Twin activity, participants reported a sense of belonging and forming new relationships. This aligns with the pilot study, indicating that Team Twin fosters a sense of belonging among runners, handiathletes and relatives (Winther et al., 2018), however no change in loneliness was observed at follow-up. This suggests that the sense of belonging may be confined to the programme and may not extend to everyday life. This perception is consistent with prior research on programs for people with disabilities, indicating that a sense of belonging to the community was more significant than friendship development outside of the program (Morris et al., 2019). Despite assessing the perceived experiences, the association between participation perception and QoL has not been explored.

Most indicated that participation in the Team Twin programme enhances a sense of belongingness, a vital construct of the participation concept (Martin Ginis et al., 2017) The highly valued and positive perception of the Team Twin programme suggests that it encompasses elements that can foster quality participation in sports and recreation for people with disabilities, as outlined in Evans et al. (2018). This aligns with findings in other studies examining participation in recreational sports that combine individuals with and without disabilities, as these programmes indicate the benefits of inclusive recreation (Jackson et al., 2019; Labbé et al., 2019; Mayer & Anderson, 2014; Orr et al., 2020).

The participants in the Team Twin programme indicated high enthusiasm and engagement in the programme. They also found fulfilment and meaning in the programme,

which is considered important for their overall health (Erlandsson et al., 2011; Martin Ginis et al., 2017). The participants' statements align with the theoretical elements that support quality participation in sports and recreational activities for people with disabilities (Evans et al., 2018). Additionally, the programme's community integration, inclusive nature and outdoor setting are essential elements in promoting both health aspects and quality participation, as these have been elaborated as vital factors in previous studies and are observed to be beneficial when participating in recreational sports activities (Chun et al., 2008; Jackson et al., 2019; Labbé et al., 2019).

Future research will use an empirical-driven approach, as outlined in the study protocol (Jørgensen et al., 2021), to capture the participants' experiences of their participation in the inclusive Team Twin programme and conduct a qualitative inquiry that could support and elaborate the findings of these preliminary observations about potential quality participation, as recommended (Ives et al., 2021; Orr et al., 2020).

Strengths and limitations

The study was conducted in a real-world setting encompassing handiathletes from six different Team Twin clubs, utilising a simple pre-post design to investigate the programme's effectiveness in authentic conditions with established Team Twin clubs. Thus, the research team did not prescribe the exercise intervention with specified exercise intensity, duration, or frequency or supervise the activities. However, this design introduces several methodological considerations. A notable strength is the preliminary testing and face validity of the applied items in the questionnaire among the population before data collection. This ensures that instruments match the participants' abilities and cognitive levels despite considerable variation (Jørgensen et al., 2021). Hence, the questionnaire was carefully selected based on prior use among the population and abstraction level consideration (e.g. employing self-efficacy and Cantril Ladder measures from the Health Behaviour in School-Age Children study (Nielsen, L. et al., 2012)). However, not all the instruments have been applied to this population previously. Therefore, despite the preliminary face validity test, the instruments may lack reliability and validity for this specific population.

The researchers acknowledge several methodological limitations to the present study. Firstly, and most importantly, there was no control group, and therefore there is no comparison to a counterfactual situation. Secondly, only 14% of the eligible population were included in the study, and 52% of the participants were already members of a Team Twin club. The majority (72%) of the experienced participants had an involuntary pause due to COVID-19 and had not actively participated in Team Twin activities for six months or longer before the intervention, arguing for a somewhat status quo-like condition prior to the intervention. However, experienced participants' established routines and expectations may influence their responses to the intervention, potentially biasing the association between the intervention and outcome. Another limitation is that the questions and statements used to assess perceived experiences were framed only positively (see Supplementary Table 1). This lack of negatively framed questions may have limited critical feedback on participants' perceptions and the identification of potential challenges. Future studies should consider including a balanced set of positively and negatively framed questions, as well as qualitative follow-up measures, to ensure a more comprehensive understanding of participant experiences.

As described, we modified our laboratory standard operating procedure due to challenges ensuring the accuracy and applicability with certain standard operating procedures applied on the target group. Modifications such as altering the water volume, adding flavour and extending the time limit for the OGTT procedure. Additionally, we used

towels and straps to help participants remain still and comfortable during the DXA scan and made sure the same number of towels were used for the next examination. The individualised adjustments affected the data obtained from the clinical assessments, leading to potential validity issues due to interference, which is why we combined the baseline measures to minimise measuring errors.

Although there was some heterogeneity in the demographics of the sample, it is likely that the participants received substantial family support and, in general, possessed the necessary mental and physical resources to engage in a research project involving repeated on-site clinical measures and multiple assessments over 16 weeks (complete assessments found in (Jørgensen et al., 2021)). Other studies have encountered disinterest in participation in experimental setups among severely disabled persons, leading to the need for redesign (Man et al., 2022). Therefore, the current sample may present a homogeneous representation of a resourceful sample supporting participation in the scientific aspect, potentially providing a biased picture of the programme's impact, as addressed in the study. Although speculative, as the study is underpowered, the per protocol analyses indicate a small significant change in QoL among individuals with lower baseline values; however, this change is not clinically relevant (<10% change). Additionally, potential selection bias may contribute to a ceiling effect, highlighting the need for future studies with a different sampling strategy that includes a more general representation of people living with severe physical disabilities. Moreover, a more robust research design with a longer intervention period, larger sample and a control group is warranted in future designs. Data collection occurred during the COVID-19 lockdown phase-out, severely restricting everyday life and social distancing. Also, as the handiathletes belong to the 'increased risk' group of citizens, extra careful social and individual considerations were warranted and officially recommended. Thus, the lack of a controlled design and other influencing factors are likely to confound the association, so findings cannot solely be attributed to the program. The relatively good baseline values for QoL and well-being may be affected by their return to everyday life with no restriction, especially considering the pandemic-related challenges (García-Rudolph et al., 2022). Thus, the COVID-19 phase-out may have influenced the mental health outcomes, resulting in a good baseline and, thus, a ceiling effect.

Conclusions

The Team Twin programme provided individuals with severe physical disabilities the opportunity to participate in recreational sports alongside peers and family members in a social setting, an environment where they are often excluded. A mean of 10 weekly sessions, each lasting approximately 77 minutes over 16 weeks, was not sufficient to show measurable improvements in the QoL score or in psychosocial and physical health indicators. However, participants expressed generally positive perceptions of their QoL and health at both baseline and follow-up, as reflected in both subjective and objective assessments. Additionally, participants expressed a sense of belonging, improvement in social relationships, and strong engagement with the activity, finding it valuable, meaningful, and motivating. Further research is needed to better understand the potential benefits of inclusive initiatives that integrate individuals with severe disabilities and peers without disabilities in community-based recreational sports activities.

Perspectives

Integrating people with and without disabilities aligns with the inclusive principles and objectives outlined in Article 30, subsection 5 of the United Nations Convention on the Rights of Persons with Disabilities (United Nations, 2006). Evidence suggests that inclusive recreational sports can positively impact psychosocial health, not only benefiting individuals

with disabilities but also those involved in the programme, including providers, peers, and families (Labbé et al., 2019; Mayer & Anderson, 2014). The Team Twin programme stands out due to its voluntary-driven approach and its integration within mainstream leisure activities, which, while argued to be beneficial (Chun et al., 2008), are often underrepresented for this subgroup of the disability community (Klenk et al., 2019; Lai et al., 2021). This represents a shift from a rehabilitation-focused approach to one that emphasises inclusive recreational sports, where athletes can experience shared goals and develop social bonds with their teammates despite inherent differences – a recreational adapted sport that is gaining increasing recognition and support in several countries outside of Denmark, as reflected in comparable initiatives such as Iron Brothers (2021), The Hoyt Foundation (2023), and The Kyle Pease Foundation (2024).

Supplementary Materials:

Supplementary Figure 1: Study design, data collection flow and measurement assessments.
Supplementary Figure 2: Flowchart depicting handiathletes' completion of clinical examinations and questionnaires. Total dropouts and participants included in the analysis, indicating full or partial assessment completion.
Supplementary Figure 3: Effectiveness analysis on participants' quality of life at 16 weeks follow-up shown for sample stratified by seniority (3A) and adherence (3B).
Supplementary Table 1: Statements formulation regarding the perceived experiences of the Team Twin programme assessed at the 16-week follow-up questionnaire (n=20).

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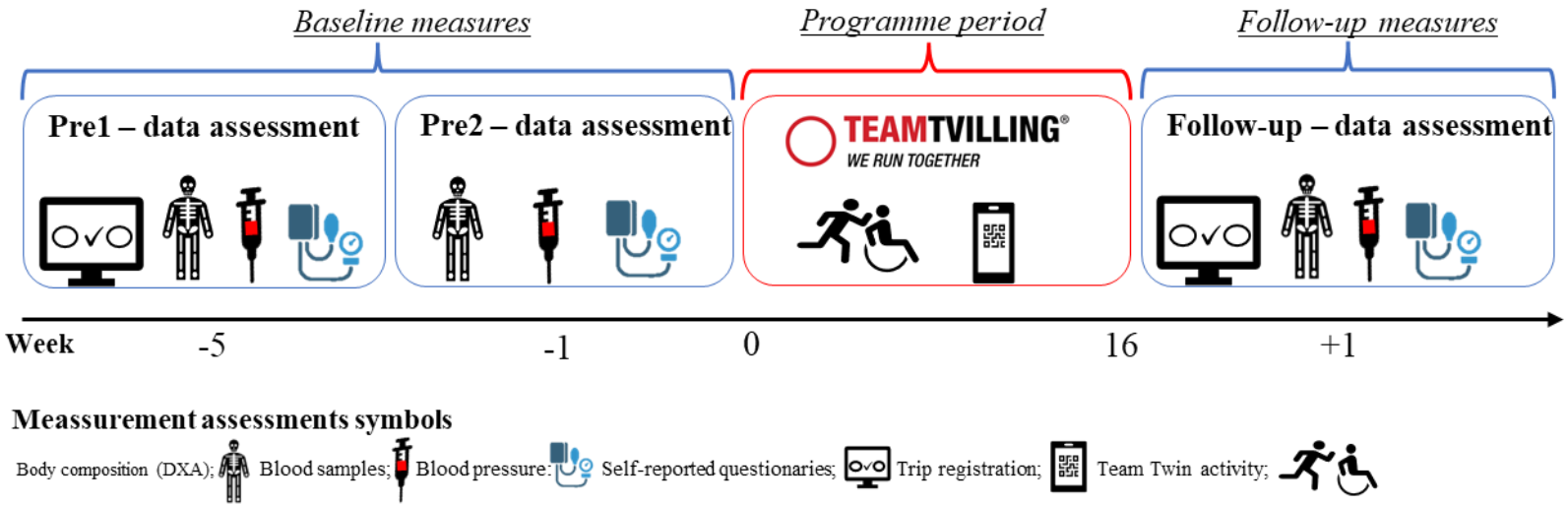
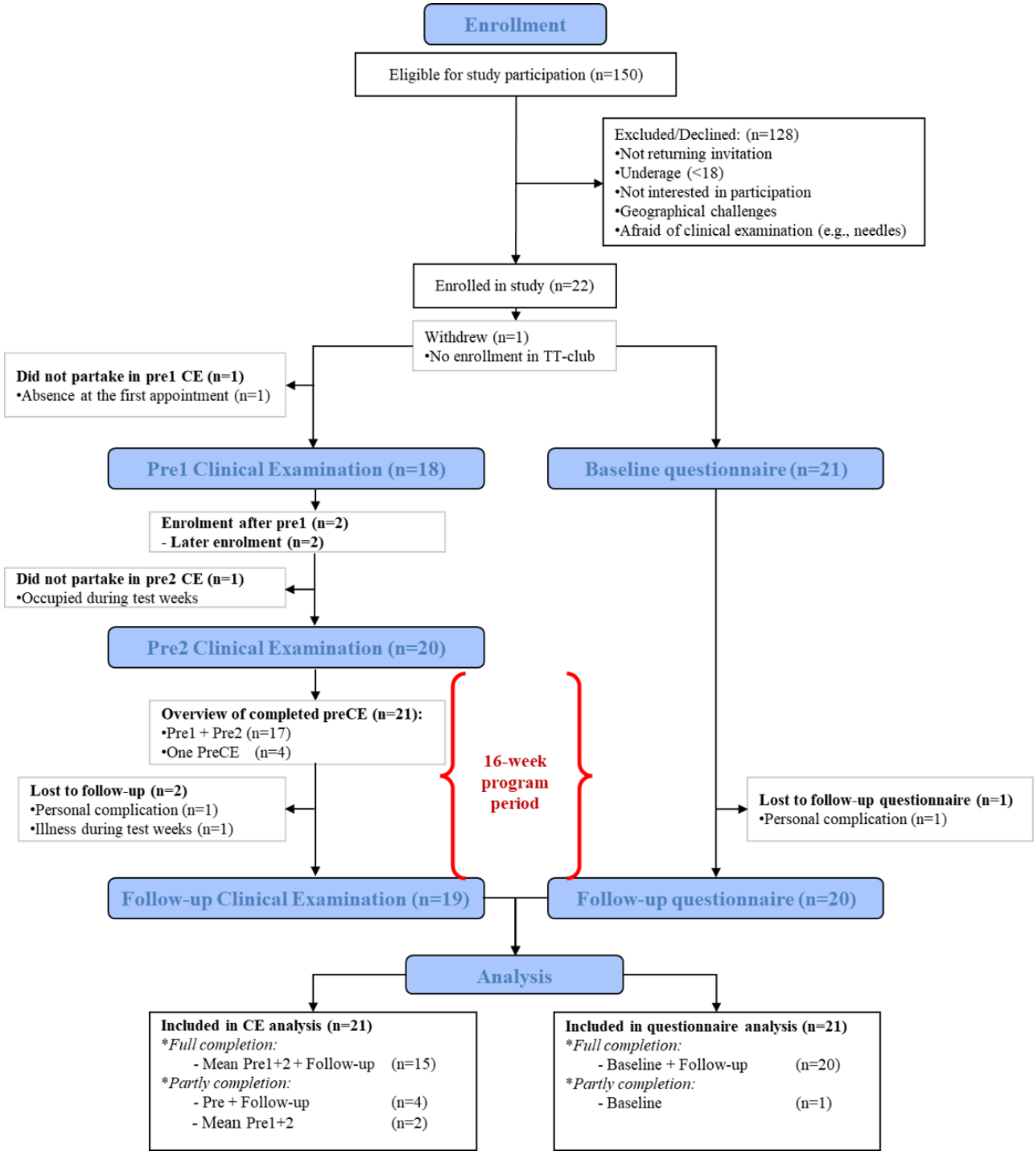
Supplementary Materials



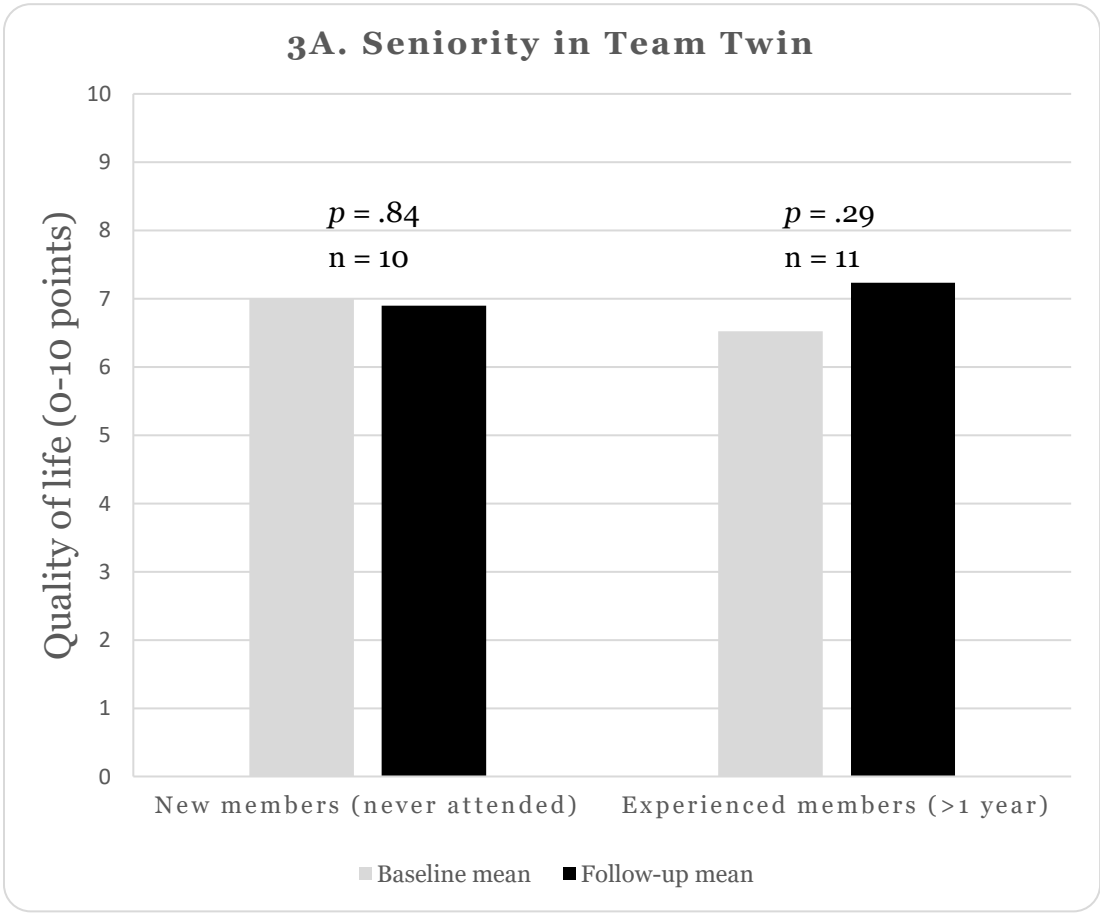
Supplementary Figure 1. Study design, data collection flow and measurement assessments.

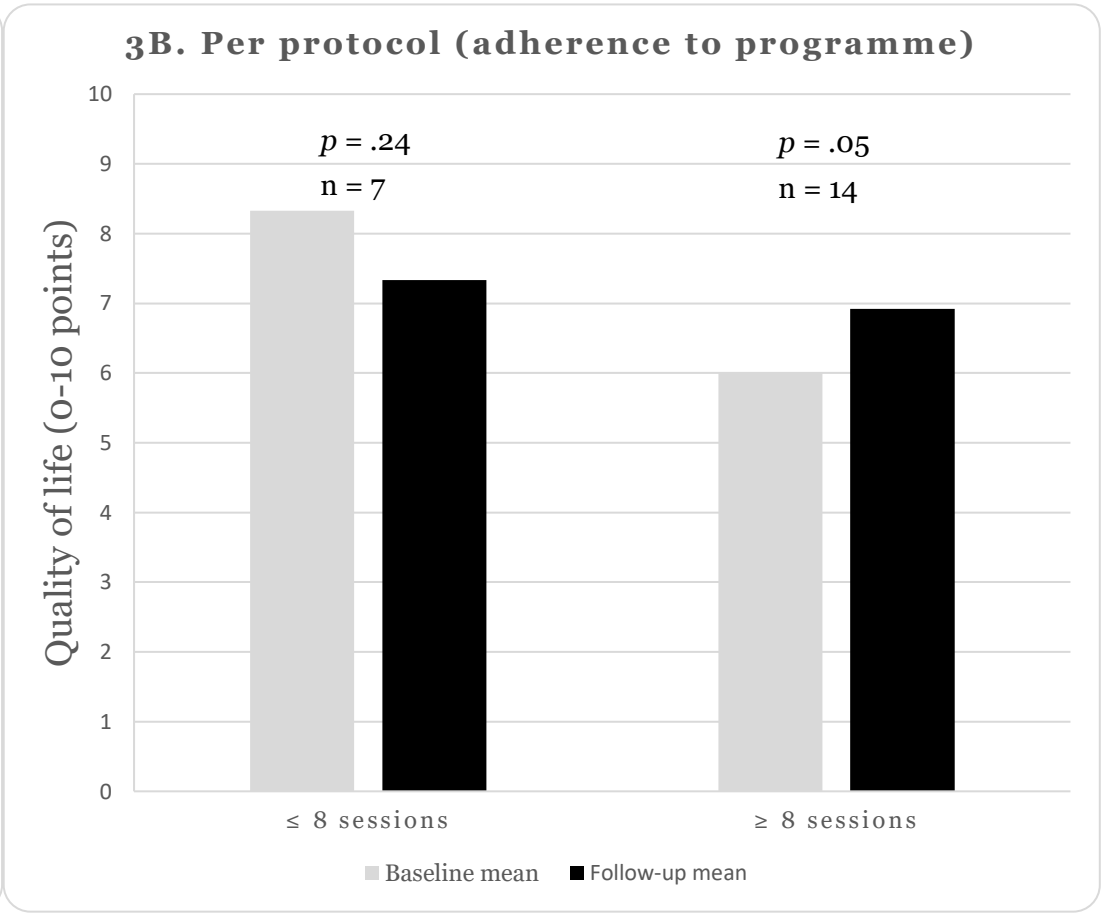
The clinical examination included tests for cardiometabolic biomarkers such as HbA1c, blood lipids (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol) and a 2-hour oral glucose tolerance test. Body composition was assessed using Dual X-ray absorptiometry (DXA) to measure whole-body lean mass, whole-body fat percentage and bone mineral density. Blood pressure was measured for systolic and diastolic office blood pressure. Participants completed questionnaires before their first clinical examination and immediately after the programme. Trip registration was completed immediately after the weekly push-assisted session by a runner.



Supplementary Figure 2. Flowchart depicting handiathletes' completion of clinical examinations and questionnaires. Total dropouts and participants included in the analysis, indicating full or partial assessment completion.

Abbreviation: CE = Clinical examination, TT=Team Twin





Supplementary Figure 3. Effectiveness analysis on participants' quality of life at 16 weeks follow-up shown for sample stratified by seniority (3A) and adherence (3B).

Supplementary Table 1. Statements formulation regarding the perceived experiences of the Team Twin programme assessed at the 16-week follow-up questionnaire (n=20).

Question number	Statements formulation
1	There is a sense of belonging in Team Twin among everyone involved
2	Team Twin gives me positive experiences with disabled athletes and runners
3	I plan to continue participating in Team Twin
4	I am motivated to participate in Team Twin
5	We support each other (in Team Twin) to reach the goals we have set
6	My family and my social circle support my participation in Team Twin
7	I have made new friends since I started and became part of Team Twin
8	In general, I have become happier in my everyday life since becoming part of Team Twin
9	I have become more extroverted since I became part of Team Twin (e.g., it is easier to interact with others)
10	I have gained a better awareness of my body (e.g., what it can do and what it can't do)
11	I am physically capable of doing more now than before my participation in Team Twin (e.g., brushing teeth, transferring back and forth in a wheelchair)

Answered on a 5-point-Likert-scale from highly agree to highly disagree