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Personalized exercise intervention in HPN patients - A feasibility study

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SUMMARY

Background: Physical health status may be predictive of readmissions, psychological health and mortality in patients with short bowel syndrome.
Aims: This study aimed to investigate the feasibility and effect of an individualized exercise intervention and secondary, oral nutrition intake counseling on Timed-Up-and-Go (TUG) and 30 s Chair Stand Test (CST) as well as body-composition and EuroQol (EQ)-5D-5L, in patients with chronic intestinal failure (IF) type III receiving HPN and/or fluid therapy.
Methods: A 12-week individualized exercise intervention consisting on three weekly home based sessions, and nutrition counselling focusing on protein intake and reducing high stoma output, was performed. Weekly follow-up by phone was done on motivation to exercise.
Results: The study invited 71 patients, 44 accepted the invitation (62%), 37(52%) were included, and 31 (84%) completed the intervention. The exercise intervention was well tolerated. TUG improved from 8.9(SD 5.5) to 7.7(SD 3.8) ($p = 0.033$). CST improved by four repetitions (<0.001*). A statistical, however not clinically relevant improvement was seen in muscle mass. No improvement was seen in (EQ)-5D-5L total, but insignificantly ($p = 0.055$) for physical function only. Protein intake improved by 10.6 g/day ($p = 0.008$).
Conclusions: A 12 weeks individualized exercise intervention showed very feasible and beneficial in HPN patients. Physical function improved statistically and clinically, and oral protein intake improved. QoL overall did not improve, however COVID-19 was an uninvited partner throughout the study period, which may have influenced general QoL. As only 62% accepted the invitation to participate, home based exercise intervention may not apply to all patients.

1. Background

Short Bowel Syndrome (SBS), also known as IF type III, is defined as “the reduction of gut function below the minimum necessary for the absorption of macronutrients and/or water and electrolytes, such that intravenous supplementation (IVS) is required to maintain health and/or growth” [1]. It is caused by various underlying pathophysiological gastrointestinal or systemic diseases such as Crohn's Disease, radiation damage, as a cause of vascular complications, large bowel resections or trauma [2–4]. In addition to the primary mechanisms the condition can be worsened in every patient, due to increased secretion of water and electrolytes in parts of the intestine that is dilated or obstructed, and patients may suffer from vomiting, anorexia, accelerated gastrointestinal transit, bacterial overgrowth in the small intestine and diarrhea. [1]. All these are symptoms that to a high degree influence patients' daily lives and activities.

Since the 1960's it has been possible to treat patients with intestinal failure by supplying fluid and nutrition via a central catheter [5]. A substantial amount of patients with SBS are not able to be

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managed on oral or enteral nutrition exclusively and require long term treatment with Home Parenteral Nutrition(HPN) [4]. The number of patients requiring HPN is strongly increasing and the incidence-rate is assumed to double every 10 years [6].

Survival with HPN depends on anatomy and function of the remaining intestine, the patients age, underlying pathophysiology, comorbidities, and the experience of the treatment team [7]. Many patients living with HPN experience bad physical health due to underlying disease, catheter-related complications, high stoma output, incontinence or stomach pains [8,9]. Many patients receiving HPN live with exhaustion, larger risk of depression and social isolation that all contributes to lower Quality of life (QoL) [10]. These symptoms have been associated to a sedentary lifestyle in patients with chronic diseases [11]. No studies are however found regarding daily activity levels in HPN-patients.

Body composition and functional capacity may be predictive of the number of readmissions, length of hospital stay and mortality [12]. Furthermore, problems as pain, oral problems, anorexia, stoma and comorbidities may further aggravate QoL and the level of Physical Function (PF) [5]. Moreover, reduced mobility has been shown to negatively affect QoL [13]. While genetic and life style factors may speed up muscle atrophy and disability, strength training interventions seem to decrease or reverse these processes [14]. Furthermore, nutrition intake counseling, focusing on qualifying patient decision making for oral intake towards reducing stoma output, may positively impact quality of life [15].

The aim of this study was to investigate the feasibility and effect of an individual home based, three times weekly exercise intervention and counseling regarding oral nutrition intake on PF measured by Timed-Up-and-Go (TUG) and 30 s Chair Stand Test (CST) as well as body-composition and QoL measured by EuroQol (EQ)-5D-5L, in patients with chronic IF type III receiving HPN and/or fluid therapy.

2. Materials and methods

This pragmatic feasibility intervention study included patients with chronic IF type III receiving HPN and/or fluid therapy at the outpatient clinic at Centre of Nutrition and Intestinal Failure (CET) at Aalborg University Hospital between November 2019 and June 2020. Furthermore, the included patients needed to be Danish speaking, past legal age, able to complete the TUG-test and able to give informed written consent. Exclusion criteria were unstable metabolic conditions i.e. catheter sepsis at the point of inclusion and unstable comorbidities like progressive cancer.

2.1. Multidisciplinary team setup

Two physicians specialized in intestinal failure and the specialist nurse, screened the patient list for relevant participants before every weekly outpatient clinic session. The nutritionist (MSc Clinical Nutrition, first author) took care of the exercise intervention and oral nutrition intake counseling, assessed the blood values. She asked the specialist physicians for advice whenever necessary, but also advised the physicians when results indicated that medical adjustments were required for i.e micronutrients, fluids or the parenteral nutrition dose. A laboratory technician performed the bioimpedance analysis and functional testing, as done routinely.

2.2. Inclusion of patients

The team head of research (last author) phoned the patients before their appointment in the outpatient clinic, giving them early information about- and invitation to join the study. If they were interested, she referred them to the nutritionist for further information and eventual inclusion. If they were interested to join, they were asked to fast for inclusion on the day of meeting in the outpatient clinic.

Most patients were included in connection with their appointment with the physician at CET if convenient for them. Patients with many other appointments on the day of meeting in the outpatient clinic, were offered inclusion in their own home.

Demographic information was collected on time of inclusion, and included age, sex, height, weight, living alone or together as well as co-morbidities.

2.3. Nutritional assessment

Height was measured to the nearest 0.5 cm and weight to the nearest 0.1 kg on a Digital electronic scale (Seca 701). At home visits the patient's own scale was used. BIA was measured using a BioScan 920-II (Maltron, Essex, UK). Patients were encouraged to fully fast for 2 h and avoid physical activity for 8 h prior to the measurement. Measurements were performed in the tetra polar position. Anthropometrics measured the same day. Patients with pacemakers and metallic implants were excluded from the bioimpedance measurement.

TUG was the primary outcome and was measured as the time it took the patients to rise from a chair, walk 3 m, turn, walk back, and sit back down. Test results were characterized as average or below average by the following normative values: <70 y: TUG<9 s, 70–80 y: TUG<10,2 s and ≥80 y: TUG<12,7 s [16]. CST was measured as the number of completed repetitions in 30 s.

The participants self-completed the EQ5D-5L-version in Danish at the time of inclusion and at the end of study.

2.4. Intervention

For initial nutritional counseling at inclusion, recent blood samples were inspected for deficiencies. If there were any deficiencies, relevant therapy was initiated. A 24-h food recall was used to address osmolarity especially regarding oral fluids, and to calculate energy- and protein intake [17,18]. Stoma output was not measured. Energy requirements were estimated by the Harris-Benedict equation [19]. Basal metabolism was multiplied by 1.1 to estimate resting energy expenditure. Total energy requirements were estimated by an activity level of 1.3 and a pragmatic absorption capacity of 60% [20]. Protein requirements were estimated for the individual between 1.0 and 1.5 G/kg/d. Typical issues discussed on the initial nutrition guidance session were stoma outputs, dehydration, a desire for weight gain or weight loss, reduced appetite, osmolarity including high oral fluid sugar intake, as well as low oral protein intake. The purpose of this counseling was to maximize the patient's outcome of the exercise intervention by reducing discomfort of individual issues including high stoma output when possible.

The exercise intervention included 5 strength training exercises: Squats/CST, plank, push-ups, shoulder press and row with bands. Patients were instructed to do a minimum of one set of 10 repetitions of each exercise with no demands for time between exercises, three times a week for 12 weeks at their home. Exercises were individualized at inclusion, so that everyone increased activity based on individual physical baseline level and the level of physical activity they usually perform. For instance, push-ups could be made either on floor on toes or knees, leaning on table, or leaning towards wall. Videos and written material with pictures of the exercises were provided for the patients, depending on individual wishes and abilities. Patients were given the opportunity to substitute one or two weekly sessions with other types of exercise, they would not

otherwise have done, for instance half an hour of fast and efficient walk.

During the 12 weeks patients were contacted weekly by phone to evaluate compliance, motivate the patient to complete the exercise program and adapt the level of the exercises when needed. Furthermore, this was an opportunity for the patient to ask questions about nutrition or other relevant issues. Some patients asked for more exercises and this was accommodated.

Hospital admissions during the intervention period were reported by patients. Compliance was evaluated as an average in percent of the weekly completed exercises during the 12 weeks. Few patients who during phone follow-up expressed difficulties to follow the exercise program, were then motivated to replace one or two weekly sessions by other types of physical activity like efficient walks for at least half an hour. This was included as compliance to the intervention. Habitual physical activity was not included.

Due to the circumstances around COVID-19, there were some exceptions to the described method, as for a period of time, researchers were not allowed physical meetings with participants. These exceptions extend only to the end of study measure for some patients. In those cases, patients were instructed by telephone to do the TUG and CST-test at their homes at 12 weeks and EQ5D-5L was done by phone interview. Some were assisted for time taking and counting by relatives and some by home-care nurse. After the quarantine period all patients had a home visit by the nutritionist and study assistant, where the remaining data were collected.

2.5. Statistical considerations

The statistics analyses were performed in R statistic software. Paired t-test and Wilcoxon Signed Rank test was used for paired group comparisons between before and after intervention measurements. Paired t-test was used when the assumption of normality was met, and Wilcoxon Signed Rank test was used if delta-data were normally distributed. Visual inspect was used to investigate whether data were normally distributed. Cox univariate regression was used for the oral covering of energy-and protein requirements. $P < 0.05$ was considered significant.

Demographic, anthropometric and clinical variables are reports as mean and standard deviation. Dropouts were excluded from the analysis.

Sample size calculation was done, and the goal was to include 35 patients. The minimal clinically important difference in TUG-test was estimated as 5 s and represents the minimal relevant difference between baseline and 3 months follow-up that's considered relevant [21]. SD was estimated as 9 s, statistical significance as $\alpha < 0.05$ and power as $\beta = 80$. In this sample size calculation is estimated a 20% dropout.

2.6. Ethical statement

The study was approved by the Regional data protection agency Reg: 2019-126. A request was submitted to the regional scientific ethics committee, which found no need for full application, as biological material was not drawn for research purposes only.

3. Results

Of the 71 patients invited to participate in this study, 44 accepted, 37 were successfully included, and 31 completed the 12 weeks intervention period. Seven patients were excluded for medical reasons as upcoming surgery.

After inclusion four dropped out, two due to severe illness in nearest family and two due to progressive disease. Furthermore, two patients were excluded due to protocol violations. In total, 83.8% of the included patients completed the 12 weeks intervention. Four patients did not have BIA measurements due to pacemakers and metallic implants (Table 1). Average compliance to the exercise intervention was 75.8%.

Of the participants, 70.1% were women. Average age was 63 years. A little more than one third lived alone at the time of inclusion. About two thirds of the participants had received HPN for >2 years. The majority of participants (41.9%) were chronic IF (CIF) patients due to inflammatory bowel disease (IBD). Cancer was the second most common cause of CIF. Other reasons included radiation damage and gastroparesis. On average patients received HPN or HP Fluids five days weekly. A large variation was seen within the HPN covering of weekly energy requirements. The most common stoma was ileostomy by 41.9%. Table 1 shows the demographic, anthropometrics and clinical information on participants at baseline.

3.1. Body composition

A statistically significant change in muscle mass (MM) ($p = 0.017$) and muscle mass index (MMI) was found ($p = 0.016$). An increase was found in all other body composition parameters besides FM% which decreased, however none were significant.). Table 2 shows measures of body composition before and after the intervention.

3.2. Physical function

A significant improvement in both TUG- ($p = 0.033$) and CST-test ($7.53*10^{-8}$) was seen after the intervention. TUG was on average improved by 1.22 s and CST by 3.53 repetitions in 30 s. Table 3 shows physical measures before and after the intervention.

3.3. Quality of life

No significant change was seen in overall EQ5D-5L score or in the VAS-score. Neither of the five dimensions were significantly changed after the intervention, but the dimension for mobility was borderline significant ($p = 0.056$). Table 4 shows results for QoL.

3.4. Other results

Oral protein intake improved from 67.7 g (SD 32.4) daily before the counseling to 78.3 (SD 37.6) grams after the intervention ($p = 0.008$). No statistical difference was seen for energy intake 1714 kcal (SD756) before the intervention, vs. 1854 (SD 771) after($p = 0.095$). In four patients, HPN doses were decreased during the intervention. Admissions were seen in 46.7% of participants during the intervention period. Admissions were due to a variety of reasons, i.e., dehydration, displacement of catheter, clotted catheter, venous thrombosis and hip surgery.

4. Discussion

This study aimed to investigate the feasibility and effect of combined individual exercise primarily focusing on strength training and oral nutrition intake counseling on PF, and secondarily body composition and QoL in patients with chronic IF type III receiving HPN and/or fluid therapy. The interventions showed feasible, as 83.8% of the included patients completed the 12 weeks intervention and average compliance to the exercise intervention was 75.8%. The individual intervention gave room for individual adjustments and weekly contacts throughout the period, may have kept patients engaged in the study. We succeeded in improving the primary endpoint, TUG, by 1.22 (13%) ($p = 0.033$) and furthermore

Table 1
Demographic, anthropometrics and clinical information on participants at baseline.

	All patients (n = 31)
Women, n (%)	22 (70.1)
Age, mean years (SD)	63.0 (14.0)
Weight, mean Kg (SD)	63.1 (16.1)
BMI mean Kg/m^2 (SD)	22.6 (5.2)
Lives alone, n (%)	12 (38.7)
Working status	
Working, n (%)	5 (16.1)
Sick leave, n (%)	3 (9.7)
Retired/early retirement, n (%)	23 (74.2)
Smoking, n (%)	7 (23.3)
>2 years with HPN, n (%)	21 (67.7)
Cause of intestinal failure	
IBD, n (%)	13 (41.9)
Cancer, n (%)	7 (22.6)
Ischemia, n (%)	3 (9.7)
Surgical complications, n (%)	2 (6.5)
Other, n (%)	6 (19.35)
Stoma	
Duodenostomy, n (%)	1 (3.2)
Jejunostomy, n (%)	2 (6.5)
Ileostomy, n (%)	13 (41.9)
Colostomy, n (%)	3 (9.7)
No stoma, n (%)	12 (38.7)
Days with HPN or HP fluids, mean (SD)	5.1 (1.8)
Percentage of energy requirements covered by HPN, mean (SD)	43.2 (31.5)

SD = standard deviation, BMI = body mass index, IBD = inflammatory bowel disease, i.v. = intravenous, HPN = home parenteral nutrition.

CTS as the other parameter for PF. This indicates a positive effect of strength training on PF in patients with chronic IF. Only one former study studied training intervention in this group of patients, and only in nine participants [22].

Furthermore, the review by Eckert et al. (2019) aimed to elucidate the effect of structured physical activity on validated clinical parameters and health-related symptoms in patients with IBD. They conclude that physical endpoints for the evaluation of PF in patients with IBD in studies investigating exercise and training interventions are barely existing [23]. Another feasibility study showed that physical activity programs were feasible in patients with Crohn's Disease, which we find relevant, since Crohn's is the dominating diagnosis in this study [24].

A floor-effect has been shown in the TUG-test among participants with a good test-result at baseline. Therefore, the test has been questioned for sensitivity towards showing improvement in patients with a mild disease course/normal functional status at the inclusion [16]. This was not the case in our study, as a significant improvement was shown.

CST was improved with four repetitions ($p < 0.01$) in 30 s after the exercise intervention. This result is not only statistically significant, but also clinically important, as an improvement of only two repetitions has shown clinically important on several outcomes in various diagnosis [25,26]. An RCT with 45 Crohn's Disease participants, randomized to control group, moderate endurance, or muscle training, also showed a significant improvement in the lower extremities measured by leg press test ($p < 0.04$) [27], while we used squats and chair stand.

Table 2
Body composition measured by weight and bioimpedance before and after intervention.

	Number	Start of study; mean, SD	End of study; mean, SD	Difference	p-value
Weight, Kg	31	63.1 (16.1)	63.6 (16.2)	−0.50	0.444
BMI, Kg/m^2	31	22.6 (5.17)	22.7 (5.20)	−0.10	0.422
FM, Kg	27	19.0 (11.6)	19.7 (11.9)	−0.71	0.587
FM, %	27	28.6 (9.49)	28.4 (10.0)	0.21	0.602
FMI	27	6.87 (4.36)	7.04 (4.50)	−0.17	0.639
FFM, Kg	27	44.0 (8.70)	46.2 (11.3)	−2.20	0.251
FFM, %	27	71.4 (9.49)	71.5 (9.62)	−0.14	0.692
FFMI	27	15.7 (1.69)	16.2 (2.49)	−0.52	0.245
MM, kg	27	20.5 (4.82)	21.4 (4.97)	−0.90	0.017*
MMI	27	7.28 (1.05)	7.53 (1.05)	−0.25	0.016*

* = statistically significant.

Table 3
Physical measures of Timed Up and Go and 30 s Chair Stand Test before and after the intervention.

	Number	Start of study; mean, SD	End of study; mean, SD	Difference	p-value
TUG, seconds	31	8.9 (5.5)	7.7 (3.8)	1.2	0.033*
CST, repetitions	30	9.3 (3.9)	13.3 (5.4)	4.0	<0.001*

* = statistically significant.

Table 4
Quality of life measured with EQ5D-5L before and after the intervention.

	N=	Start of study; mean, SD	End of study; mean, SD	Difference	p-value
EQ5D-5L total score	31	0.75 (0.13)	0.78 (0.14)	−0.03	0.184
Mobility	31	1.94 (1.1)	1.7 (0.9)	0.3	0.056
Self-care	31	1.2 (0.4)	1.4 (0.6)	−0.2	0.265
Usual activities	31	2.1 (0.1)	1.9 (0.9)	0.2	0.459
Pain/discomfort	31	2.5 (0.9)	2.2 (0.9)	0.3	0.095
Anxiety/depression	31	1.4 (0.6)	1.3 (0.7)	0.1	0.262
VAS-score	31	63.7 (18.0)	66.2 (20.4)	−2.5	0.494

In their pilot study with 9 participants after an extensive small bowel resection, Araújo et al. (2008) found a significant increase in MM after a 14 weeks training intervention in patients with IBD [22]. Their training program was progressive and lasted for 60 min twice a week, and they found a significant increase in MM, FFM, and total circumference of the upper arm. The Patients in the study by Araújo et al. (2008) may be similar to those included in this study, however our patients were older, and we suspect that 1 h of exercise would exclude some of our participants along the way. The participants in the study by Araújo et al. (2008) are considered stable but more than half of the participants were readmitted during the intervention, as in our study. We know, however by experience, that hospitalizations are common in this group of patients. In our study we did not differ between planned and unplanned hospitalizations, however we estimate, that unplanned admissions may be similar to the 33% found by Burden et al. [28].

In a cross over RCT, Cronin et al. (2019) studied FFM in 13 patients with IBD with DEXA-scan and found a significant increase in FFM after a strength training intervention for eight weeks compared to a decrease of FFM in the control group [29]. Participants were significantly younger and with a higher BMI than in the present study, which makes it difficult to compare the results. Likewise, significant changes in body composition measured with BIA were found after eight weeks of individualized training programs for patients with Crohn's Disease [24].

No significant changes were found in the total EQ5D-5L score, the VAS-score or the five dimensions after the 12-weeks exercise intervention. While QoL has shown decreased in HPN patients compared to the general population [13], no studies have made the attempt to improve QoL in this patient group by external factors, such as exercise or training [22]. The unwished partnership with the Corona virus during the intervention period, may have influenced quality of life in our participants, as in other patients with chronic illness and a lower general level of quality of life [30]. Furthermore, differences in quality of life may not be visible by the use of EQ5D-5L, as this tool was used primarily because it was manageable for the patients, including easy to use and understand. Even though it was used in a similar population before, it may not be sensitive enough to detect differences in this group and sample of patients [13].

4.1. Strengths and limitations

The study is strengthened by the setting being a highly specialized centre for treating patients with intestinal failure in a multi-professional context. Furthermore, systematic nutritional assessment is well known to this cohort of patients. This centre receives patients from a well-defined geographical area (around 2.1 mill inhabitants out of 6 mill) and thus the population is representative for the Danish HPN population.

There are several limitations to this study. Generally, it has been a challenge to continue the study by protocol due to the shutdowns from the COVID-19 pandemic. The final data collection was made after 12 weeks. In a few cases this was not possible due to Covid shut-down, admissions or personal events in participants lives. Accordingly, there was a variation between data collection times for some between 11 and 13 weeks.

The exercise intervention was customized to fit individual level at inclusion. Few participants scored with a higher compliance without following their customized exercise program because they instead succeeded to perform other physical activity as agreed. This is a limitation because it can bias the effect of the designed exercise intervention – but chosen because of the primary desire to investigate if a twelve-week exercise intervention was at all feasible in HPN-patients, and if PF and QoL could be improved. The few included patients may be a limitation to the lacking significant results regarding body composition measures. As this study was found feasible, we would suggest a larger RCT including HPN patients in an exercise intervention with a flexible exercise arm, a strict strength training arm and controls. This study would however require more patients than our population can accommodate alone.

5. Conclusions

This study showed it feasible as well as effective to perform a 12 weeks individual program combining exercise and oral nutrition intake counseling focused on osmolarity and protein intake with a nutritionist in chronic IF type III receiving HPN and/or fluid therapy. Physical function measured by TUG and CST showed statistical as well as clinical improvements. Counselling for oral intake improved protein intake. Sample size was too small to show improvements on body composition and QoL. This study may provide the basis for calculating sample size for a very much welcomed RCT with physical exercise intervention in Chronic IF patients.

Statement of authorship

SG and MH made the conception and design of the study. SG performed the intervention, analysis and interpretation of data assisted by LG. HHR and LVJ secured and supervised the medical therapy during the project. JRA and MH supervised the project. SG and MH wrote the first edition of the manuscript. All authors approved the final version to be submitted.

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None.

Declaration of competing interest

The authors have no conflicts of interest for this study.

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References

[1] Pironi L, Arends J, Baxter J, Bozzetti F, Peláez RB, Cuerda C, et al. ESPEN endorsed recommendations: definition and classification of intestinal failure in adults. Clin Nutr 2015;34:171–80. https://doi.org/10.1016/j.clnu.2014.08.017.
[2] Nightingale J, Woodward JM. Guidelines for management of patients with a short bowel. Gut J 2006;55:1–12. https://doi.org/10.1136/gut.2006.091108.
[3] Pironi L, Arends J, Bozzetti F, Cuerda C, Gillanders L, Jeppesen PB, et al. ESPEN guidelines on chronic intestinal failure in adults. Clin Nutr 2016;35:247–307. https://doi.org/10.1016/j.clnu.2016.01.020.
[4] Keller J, Panter H, Layer P. Management of the short bowel syndrome after extensive small bowel resection. Best Pract Res Clin Gastroenterol 2004;18:977–92. https://doi.org/10.1016/j.bpg.2004.05.002.
[5] Howard L. Home parenteral nutrition: survival, cost, and quality of life. Gastroenterology 2006;130:52–9. https://doi.org/10.1053/j.gastro.2005.09.065.
[6] Staun M, Pironi L, Bozzetti F, Baxter J, Forbes A, Joly F, et al. ESPEN guidelines on parenteral nutrition: home parenteral nutrition (HPN) in adult patients. Clin Nutr 2009;28:467–79. https://doi.org/10.1016/j.clnu.2009.04.001.
[7] Parrish CR, Dibaise JK. Managing the adult patient with short bowel syndrome. Gastroenterol Hepatol (N Y) 2017;13:600–8.
[8] Bech LF, Drustrup L, Nygaard L, Skallerup A, Christensen LD, Vinter-Jensen L, et al. Environmental risk factors for developing catheter-related bloodstream infection in home parenteral nutrition patients: a 6-year follow-up study. JPEN J Parenter Enteral Nutr 2016;40:989–94. https://doi.org/10.1177/0148607115579939.
[9] Christensen LD, Holst M, Bech LF, Drustrup L, Nygaard L, Skallerup A, et al. Comparison of complications associated with peripherally inserted central catheters and Hickman™ catheters in patients with intestinal failure

receiving home parenteral nutrition. Six-year follow up study. Clin Nutr 2016;35:912–7. https://doi.org/10.1016/j.clnu.2015.06.009.
[10] Burden S, Jones D, Gittins M, Ablett J, Taylor M, Mountford C, et al. Need-based quality of life in adults dependent on home parenteral nutrition. Clin Nutr 2019;38:1433–8. https://doi.org/10.1016/j.clnu.2018.06.964.
[11] McInnis LA, Morehead A. Exercise as a therapeutic intervention. Nurs Clin North Am 2020;55:543–56. https://doi.org/10.1016/j.cnur.2020.06.019.
[12] Køhler M, Schou S, Højgaard H. Body composition predicts clinical outcome in patients with intestinal failure on long-term home parenteral nutrition. Clin Nutr ESPEN 2018;28:193–200. https://doi.org/10.1016/j.clnesp.2018.08.004.
[13] HolstM,RyttergaardL,FrandsenLS,Vinter-JensenL,RasmussenHH.QualityoflifeinHPNpatientsmeasuredbyEQ5D-3LincludingVAS.JClinNutrMetab2018;1–5.
[14] Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia : revised European consensus on de fi nition and diagnosis. Age Ageing 2019;48:16–31. https://doi.org/10.1093/ageing/afy169.
[15] Sobocki J, Zaczek Z, Jurczak P, Lachowicz K, Kunecki M, Groszek P, et al. Restricted *v* . unrestricted oral intake in high output end-jejunostomy patients referred to reconstructive surgery. Br J Nutr 2020:1–7. https://doi.org/10.1017/S0007114520003360.
[16] Bennell K, Dobson F, Hinman R. Measures of physical performance assessments: self-Paced walk test (SPWT), stair climb test (SCT), six-minute walk test (6MWT), chair STand test (CST), timed up & Go (TUG), sock test, lift and carry test (LCT), and car task. Arthritis Care Res (Hoboken) 2011;63:350–70. https://doi.org/10.1002/acr.20538.
[17] Sharma M, Rao M, Jacob S, Jacob CK. Validation of 24-hour dietary recall: a study in hemodialysis patients. J Ren Nutr Off J Counc Ren Nutr Natl Kidney Found 1998;8:199–202. https://doi.org/10.1016/s1051-2276(98)90018-8.
[18] Holst M, Ofei KT, Skadhauge LB, Rasmussen HH, Beermann T. Monitoring of nutrition intake in hospitalized patients: can we rely on the feasible monitoring systems? J Clin Nutr Metab 2017;1. https://doi.org/10.4172/jcnm1000102.
[19] Harris JA, Benedict FG. A biometric study of human basal metabolism. Proc Natl Acad Sci U S A 1918;4:370–3. https://doi.org/10.1073/pnas.4.12.370.
[20] Rodrigues CA, Lennard-Jones JE, Thompson DG, Farthing MJ. Energy absorption as a measure of intestinal failure in the short bowel syndrome. Gut 1989;30:176–83. https://doi.org/10.1136/gut.30.2.176.
[21] Pardasaney PK, Latham NK, Jette AM, Wagenaar RC, Ni P, Slavin MD, et al. Sensitivity to change and responsiveness of four balance measures for community-dwelling older adults. Phys Ther 2012;92:388–97. https://doi.org/10.2522/ptj.20100398.
[22] Araújo ECF, Suen VMM, Marchini JS, Vannucchi H. Muscle mass gain observed in patients with short bowel syndrome subjected to resistance training. Nutr Res 2008;28:78–82. https://doi.org/10.1016/j.nutres.2007.12.007.
[23] Eckert KG, Abbasi-Neureither I, Köppel M, Huber G. Structured physical activity interventions as a complementary therapy for patients with inflammatory bowel disease - a scoping review and practical implications. BMC Gastroenterol 2019;19. https://doi.org/10.1186/s12876-019-1034-9.
[24] Geisler L, Ubbesen N, Søndergaard J, Jørgensen LQ, Sam T, Christensen T, et al. Clinics in gastroenterology eight-weeks individualized exercise program targeted for patients with Crohn â€™s disease: a feasibility study. Clin Gastroenterol 2020;2:17–21.
[25] Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Rea Q Exerc Sport 1999;70:113–9.
[26] Zanini A, Crisafulli E, D'Andria M, Gregorini C, Cherubino F, Zampogna E, et al. Minimal clinically important difference in 30 second sit-to-stand test after pulmonary rehabilitation in patients with COPD. Eur Respir J 2018;52:OA5199. https://doi.org/10.1183/13993003.congress-2018.OA5199.
[27] Seeger WA, Thieringer J, Esters P, Allmendinger B, Stein J, Schulze H, et al. Moderate endurance and muscle training is beneficial and safe in patients with quiescent or mildly active Crohn's disease. United Eur Gastroenterol J 2020;8:804–13. https://doi.org/10.1177/2050640620936383.
[28] Burden S, Hemstock M, Taylor M, Teubner A, Roskell N, MacCulloch A, et al. The impact of home parenteral nutrition on the burden of disease including morbidity, mortality and rate of hospitalisations. Clin Nutr ESPEN 2018 Dec:222–7. https://doi.org/10.1016/j.clnesp.2018.07.006.
[29] Cronin O, Barton W, Moran C, Sheehan D, Whiston R, Nugent H, et al. Moderate-intensity aerobic and resistance exercise is safe and favorably influences body composition in patients with quiescent Inflammatory Bowel Disease: a randomized controlled cross-over trial. BMC Gastroenterol 2019;19:1–11. https://doi.org/10.1186/s12876-019-0952-x.
[30] Horesh D, Kapel Lev-Ari R, Hasson-Ohayon I. Risk factors for psychological distress during the COVID-19 pandemic in Israel: loneliness, age, gender, and health status play an important role. Br J Health Psychol 2020;25:925–33. https://doi.org/10.1111/bjhp.12455.