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The Course of Physical Capacity in Wheelchair Users During Training for the HandbikeBattle and at 1-Yr Follow-up

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Objective: The aims of this study were (1) to compare physical capacity at 1-yr follow-up with physical capacity before and after the training period for the HandbikeBattle event and (2) to identify determinants of the course of physical capacity during follow-up.

Design: This was a prospective observational study. Former rehabilitation patients ($N = 33$) with health conditions such as spinal cord injury or amputation were included. A handcycling/arm crank graded exercise test was performed before (January, T1) and after the training period (June, T2) and at 1-yr follow-up (June, T4). Outcomes were peak power output (W) and peak oxygen uptake (L/min). Determinants were sex (male/female); age (years); classification; physical capacity, musculoskeletal pain, exercise stage of change, and exercise self-efficacy at T1; and HandbikeBattle participation at T4.

Results: Multilevel regression analyses showed that peak power output and peak oxygen uptake increased during the training period and did not significantly change during follow-up (T1: 112 ± 37 W, 1.70 ± 0.48 L/min; T2: 130 ± 40 W, 2.07 ± 0.59 L/min; T4: 126 ± 42 W, 2.00 ± 0.57 L/min). Participants who competed again in the HandbikeBattle showed slight improvement in physical capacity during follow-up, whereas participants who did not compete again showed a decrease.

Conclusion: Physical capacity showed an increase during the training period and remained stable after 1-yr follow-up. Being (repeatedly) committed to a challenge might facilitate long-term exercise maintenance.

Key Words: Cardiorespiratory Fitness, Longitudinal Studies, Rehabilitation, Exercise

(*Am J Phys Med Rehabil* 2021;100:858–865)

What Is Known

- Physical capacity in wheelchair users is generally low. Exercise interventions have shown positive effects on physical capacity. However, exercise maintenance on the long term is a challenge and determinants for long-term exercise maintenance are largely unknown.

What Is New

- This study showed that improvements in physical capacity as a result of training could be maintained during 1-yr follow-up and that training toward a (new) goal was the most important determinant for stable physical capacity levels in the long-term. Therefore, these results could point at the effectiveness of commitment to a challenge to facilitate long-term exercise maintenance.

Physical capacity is the combined outcome of muscle strength, respiratory function, and cardiovascular function.[1] The gold standard to measure the aerobic component of physical capacity is a graded exercise test (GXT) until volitional exhaustion with outcome parameters peak oxygen uptake (VO_2peak, L/min) and peak power output (POpeak, W). Wheelchair users generally have a low physical capacity compared with able-bodied individuals.[2] Apart from disability, this is due to the lower muscle mass in the upper body compared with the legs, but also to a more sedentary/inactive lifestyle. In previous studies, improvements in physical capacity were associated with a lower risk for cardiovascular disease,[3] a higher chance to return to work,[4] and a higher life satisfaction.[5] Therefore, exercise interventions to increase upper-body physical capacity are important.

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Funded by HandicapNL, Stichting Mitialto, Stichting Beatrixoord Noord-Nederland, University Medical Center Groningen, Heliomare Rehabilitation Center, and Stichting Handbike Events.

Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.ajpmr.com).

ISSN: 0894-9115
DOI: 10.1097/PHM.0000000000001658

Several studies have shown the positive effects of exercise on upper-body physical capacity in wheelchair users.[6–9] Exercise maintenance on the long-term is, however, a challenge. In a previous follow-up study, which was undertaken 3 mos after a controlled twice-weekly training study for 9 mos in individuals with spinal cord injury (SCI), exercise adherence dropped from 80.6% to 42.7%.[7,10] Possible explanations mentioned by the authors were (1) the obligation that participants felt to come to the laboratory during the controlled laboratory-based study and the lack of this obligation during follow-up; (2) the presence of a goal, that is, completing the 9-mo study and the absence of a goal during follow-up; and (3) the degree of pain, which had an explained variance of 83% for exercise adherence during follow-up.[10] In a previous study on leisure time physical activity in individuals with SCI, it was shown that important factors for being stably active over time were not having pressure ulcers, higher levels of exercise intentions, less severe SCI, age (being younger), and fewer years postinjury.[11]

With respect to behavioral change and adopting or maintaining an active lifestyle, behavioral change models focus on several important constructs that are a prerequisite for engaging in exercise behavior. Examples of important constructs are the attitude toward exercise (exercise stage of change) and one's confidence to regularly engage in physical activity and exercise (exercise self-efficacy).[12–15] These constructs are thought to be both static and dynamic in nature and could therefore predict certain behavior, but could also be influenced and change over time.

Handcycling is a common mode of exercise for wheelchair users in the Netherlands. Today, handcycling is introduced already early in rehabilitation and is an easy mode to practice and cover larger distances at relatively high speeds. This can be explained by the higher efficiency and consequent higher power output (in W) in handcycling, while also accompanied by lower shoulder loads compared with handrim wheelchair propulsion.[16,17] Considering the beneficial effects of handcycling and the potential stimulating effect of training toward a goal, the HandbikeBattle was organized for the first time in 2013.[18] In this Dutch annual event in the mountains of Austria, teams from 12 Dutch rehabilitation centers participate. Each team consists of former rehabilitation patients with a chronic disability such as a SCI, amputation, or cerebral palsy. Before the event in June, participants train for a period of 4–5 mos. At the start of the training period, most participants are relatively untrained handcyclists. Guidance during the training period is provided by therapists from the respective rehabilitation centers, but otherwise the training is self-organized and free-living for the full period; that is, no specific training program is provided by the researchers. The aim of the training period and event is that participants learn to adopt an active lifestyle, experience positive effects in daily life, and continue to participate in sports on the long-term. Previous studies have shown that training for the HandbikeBattle event results in improvement in physical capacity during the training period.[5,6] Long-term effects on physical capacity are, however, unknown. It is expected that participants who completed the HandbikeBattle are likely to maintain an active lifestyle because the training was not laboratory based but self-organized in their own environment, they were physically active during the training period and possibly experienced positive effects of this lifestyle, and they have fewer barriers because they overcame certain barriers during the training period. The maintenance of this active lifestyle would result in stable levels of physical capacity at long-term follow-up.

The purposes of the present study, therefore, were (1) to compare physical capacity 1 yr after the HandbikeBattle event with physical capacity before and after the training period and (2) to identify determinants that influence the course of physical capacity during follow-up.

METHODS

Participants

Inclusion criteria for the HandbikeBattle event were being a former rehabilitation patient from 1 of the 12 participating rehabilitation centers; impairment of the lower limbs due to, for example, SCI, amputation, cerebral palsy, or spina bifida; and commitment to participate in the HandbikeBattle event. Exclusion criterion included contraindications to participate in the HandbikeBattle as diagnosed during the medical screening. In the present study, data were used from participants of the HandbikeBattle 2017 and 2018 cohorts ($N = 125$). Of 12 rehabilitation centers, 4 were able (considering logistics, time constraints, and financial situation) to conduct a follow-up GXT for the 2017 and 2018 cohorts 1 yr after participation (in June 2018 and June 2019, respectively). As a result, 53 former HandbikeBattle participants were asked to perform a follow-up GXT 1 yr after their participation in the HandbikeBattle event. All participants voluntarily signed an informed consent form. The study was approved by the Local Ethics Committee of the Center for Human Movement Sciences, University Medical Center Groningen, the Netherlands (ECB/2012_12.04_l_rev/Ml) in accordance with the Declaration of the World Medical Association. This study conforms to all STROBE guidelines and reports the required information accordingly (see Supplemental Checklist, Supplemental Digital Content 1, http://links.lww.com/PHM/B180).

Procedure

The HandbikeBattle study has a prospective observational design. Measurements are performed at the start of the training period (January, T1); after the training period, before the event (June, T2); at follow-up, 4 mos after the event (October/November, T3); and at follow-up, 1 yr after the event (June, T4) (Fig. 1). At T1, a medical screening was performed by a rehabilitation physician or sports physician, which comprised a medical anamnesis, physical examination, and a handcycling/arm crank GXT. At T2 and T4, the GXT was repeated with the same protocol and equipment. At all time points, participants were asked to fill out questionnaires about musculoskeletal pain, exercise stage of change, and exercise self-efficacy.

Physical Capacity

At T1, T2, and T4, physical capacity was measured during a synchronous incremental handcycling/arm crank GXT to volitional exhaustion. The GXTs were organized in and conducted by the staff of each of the participating rehabilitation centers. Dependent on the rehabilitation center, the GXTs were performed with the use of an arm ergometer (Lode Angio, Groningen, the Netherlands) or a recumbent sport handcycle attached to the

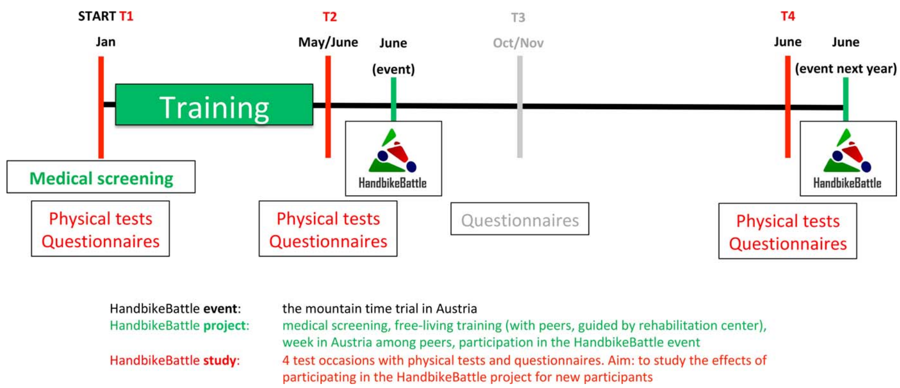

FIGURE 1. The design of the HandbikeBattle study. Time point T3 was not taken into account for the analyses in the present study.

Cyclus 2 ergometer (RBM elektronik-automation GmbH, Leipzig, Germany). Either a 1-min step protocol or continuous ramp protocol was used and was individualized for each participant. For the 1-min protocol, the test started at 5–100 W with increments of 5–15 W/min. For the ramp protocol, the test started at 0 or 20 W with increments of 1 W/12 secs (5 W/min), 1 W/10 secs (6 W/min), 1 W/6 secs (10 W/min), 1 W/4 secs (15 W/min), or 1 W/3 secs (20 W/min). The selection of the appropriate protocol per participant was based on expert opinion of the test assistant. The set-up and protocol choice were consistent within participants over time. Power output (W), heart rate (HR) (bpm), and gas exchange were measured during the test. Directly after termination of the test, participants were asked to score their perceived exertion (i.e., rating of perceived exertion) during the final stage on a scale from 0 to 10 (Modified CR-10 scale). Data of the GXT were assessed with the following criteria: peak HR ≥95% × (200 − age), a rating of perceived exertion of 7 or higher, and a peak respiratory exchange ratio (RERpeak) of 1.10 or higher.[19] Outcome parameters for physical capacity were POpeak and VO_2peak. For the 1-min protocol, POpeak was defined as the highest power output that was maintained for at least 30 secs. For the ramp protocol, the highest power output achieved during the test was considered POpeak. Peak HR was defined as the highest HR achieved during the test. VO_2peak and RERpeak were defined as the highest 30-sec average for VO_2 and respiratory exchange ratio, respectively.

Determinants

Possible determinants that could explain differences among participants during follow-up were sex (male/female), age (years), physical capacity at T1, handcycling classification, musculoskeletal pain at T1, exercise stage of change at T1, exercise self-efficacy at T1, and whether participants were going to participate again in the HandbikeBattle event at the time of their follow-up GXT (T4).

Handcycling classification was used as a proxy for severity of impairment and determined by a Union Cycliste Internationale-certified Paracycling classifier, following the Union Cycliste Internationale Para-cycling Regulations. This results in five classes, ranging from H1 (most impaired) to H5 (least impaired).[20] H1 and H2 handcyclists have limitations in arm-hand function, whereas H3 has intact arm-hand function and limitations in trunk and lower limbs. Handcyclists with impaired HR response to exercise are represented in class H1–H3. H4 and H5 handcyclists have limitations in lower limbs only. For the analyses in the present study, participants were divided in two groups of equal size: (1) H1–H3 and (2) H4–H5.

Musculoskeletal pain comprised seven locations (hand/wrist [L/R], elbow [L/R], shoulder [L/R] and neck), with a range from 1 (no pain) to 6 (very severe pain). Having moderate–severe pain was defined as 4 (moderate pain) or higher at one or more locations. Two groups were created: (1) no–mild pain and (2) moderate–severe pain.

Exercise stage of change was measured with one question where participants had to select one of five statements reflecting their current exercise behavior. In these statements, the five stages of change were reflected: (1) precontemplation (no intention to become active), (2) contemplation (considering becoming active), (3) preparation (irregularly active), (4) action (regularly active for <6 mos) and (5) maintenance (regularly active for >6 mos).[13] For analyses, two groups were created: (1) 1–3 and (2) 4–5.

Exercise self-efficacy was measured with the Exercise Self-Efficacy Scale consisting of 10 items about self-confidence with respect to physical activity and exercise.[21] All items had a 4-point scale ranging from not at all true (1) to always true (4). A sum score of the 10 items was calculated ranging from 10 (lowest self-efficacy) to 40 (highest self-efficacy).

Statistical Analyses

The analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 24.0; IBM Corp, Armonk, NY) and MLwiN version 3.02.[22] Descriptive statistics were calculated for outcome parameters and determinants. Outcome parameters were tested for normality with the Kolmogorov-Smirnov test with Lilliefors significance correction and the Shapiro-Wilk test, combined with *z*-scores for skewness and kurtosis. Individuals that performed the follow-up GXT (participants, $n = 33$) were compared on baseline characteristics with individuals who did not perform the follow-up GXT (nonparticipants, $n = 20$). Baseline characteristics were compared using independent-samples *t* tests, Mann-Whitney *U* tests, and chi-squared tests.

To account for the dependency of the observations within participants (T1, T2, T4) and participants within centers, three-level multilevel models were created with observations within participants (T1, T2, T4) as first level, participant as second level, and rehabilitation center as third level.[23] Rehabilitation center was added as level to correct for potential differences in test setting/testers/protocols between the rehabilitation

TABLE 1. Characteristics and outcomes at T1 for participants and nonparticipants

Characteristics	*n*	Participants	*n*	Nonparticipants
Sex (male/female), *n* (%)	33	22/11 (67/33)	20	16/4 (80/20)
Age, mean (SD), years	33	40 (14)	20	41 (14)
Body mass, mean (SD), kg	30	76 (22)	20	78 (22)
Impairment type, *n* (%)	33		20	
Spinal cord injury		17 (52)		12 (60)
Tetraplegia		2 (6)		2 (10)
Paraplegia		15 (46)		10 (50)
Amputation		3 (9)		2 (10)
Cerebral palsy		3 (9)		3 (15)
Stroke		2 (6)		0 (0)
Multitrauma		1 (3)		1 (5)
Spina bifida		1 (3)		1 (5)
Other		6 (18)		1 (5)
POpeak, W, mean (SD)	33	112 (37)	20	107 (41)
VO_2peak, L/min, mean (SD)	32	1.70 (0.48)	20	1.73 (0.56)
Handcycling classification (H1–H3/H4–H5), *n* (%)	33	16/17 (48/52)	20	10/10 (50/50)
Musculoskeletal pain (no–mild/moderate–severe), *n* (%)	26	15/11 (58/42)	17	9/8 (53/47)
Exercise stage of change (1–3/4–5), *n* (%)	24	4/20 (17/83)	17	2/15 (12/88)
Exercise self-efficacy, mean (SD)	24	35.8 (3.5)	17	35.1 (4.4)

Handcycling classification: two categories: (1) H1–H3 and (2) H4–H5. Musculoskeletal pain: two categories: (1) no–mild pain and (2) moderate–severe pain. Exercise stage of change: two categories: (1) 1–3 and (2) 4–5. There were no significant differences between the groups at baseline.

centers. Two models were created with either POpeak or VO_2peak as dependent variable. In each model, time (T1, T2, T4) was included as a categorical variable with two dummies and T2 as reference category.

To study determinants that influence the course of physical capacity during follow-up (T4), interaction terms with the time dummies were investigated in a series of separate models for each of the following determinants: sex (reference: male), age (years), physical capacity at T1, handcycling classification (reference: H1–H3), musculoskeletal pain at T1 (reference: no–mild pain), exercise stage of change at T1 (reference: 1–3), exercise self-efficacy at T1, and whether participants were going to participate again in the HandbikeBattle event at T4 (reference: no).

RESULTS

Of the 53 participants who were asked to perform a follow-up GXT, 20 did not successfully perform the GXT, whereas 33 were successful. Reasons for not performing the GXT at T4 were medical reasons (*n* = 5, which were psychologic problems [*n* = 2], severe back pain, allergic reaction, and illness not specified), motivational problems (*n* = 2), time constraints (*n* = 1), family matters (*n* = 1), loss of contact (*n* = 4), and unknown reasons (*n* = 4), and one former participant died. Two more individuals were excluded as their follow-up GXT was performed with a different protocol from their previous GXTs. Hence, data from 33 individuals were used in the present study. There were no significant differences at baseline between participants and nonparticipants (Table 1). Both outcome parameters were normally distributed. Participants were classified with the following distribution: H1, *n* = 0; H2, *n* = 3; H3, *n* = 13; H4, *n* = 9; H5, *n* = 8. Of the 33 participants, 18 competed again in the HandbikeBattle event at the time of T4 (competitors at follow-up), whereas 15 participants did not compete again (noncompetitors at follow-up).

Longitudinal Trajectory of Physical Capacity

Physical capacity over time is shown in Table 2. At group level, POpeak and VO_2peak showed a significant increase between

TABLE 2. Outcome parameters of participants at all time points

	n	T1	*n*	T2	*n*	T4
POpeak, W	33	112 (37)	32	130 (40)	33	126 (42)
VO_2peak, L/min	32	1.70 (0.48)	32	2.07 (0.59)	32	2.00 (0.57)
HRpeak, bpm,	33	174 (17)	32	174 (19)	33	172 (20)
RERpeak	32	1.28 (0.12)	31	1.26 (0.14)	32	1.22 (0.12)
RPE at peak	23	7.5 (1.7)	25	8.0 (1.5)	29	8.4 (1.3)
Test duration, min	33	9.8 (2.8)	32	10.9 (2.3)	33	10.4 (2.5)

Data represent mean (SD). T1 indicates start of the training period; T2, after the training period, before the HandbikeBattle event; and T4, follow-up measurement, 1 yr after the event.

HRpeak indicates peak HR; RERpeak, peak respiratory exchange ratio; RPE, rating of perceived exertion (range, 0–10).

TABLE 3. Longitudinal trajectory of physical capacity

		Constant (Reference: T2)	Δ T2–T1		Δ T2–T4	
	n	Regression Coefficient (SE)	Regression Coefficient (SE)	*P*	Regression Coefficient (SE)	*P*
POpeak, W	33	128.37 (6.91)	−15.21 (3.02)	<0.001	−2.43 (2.91)	0.40
VO_2peak, L/min	32	2.05 (0.10)	−0.32 (0.06)	<0.001	−0.05 (0.06)	0.34

T1 indicates start of the training period; T2, after the training period, before the HandbikeBattle event; T4, follow-up measurement, 1 yr after the event. For Δ T2–T1, a negative regression coefficient represents an improvement of the dependent variable over time. For Δ T2–T4, a negative regression coefficient represents a deterioration of the dependent variable over time.

T1 (start training) and T2 (after training) and did not significantly change between T2 and T4 (1-yr follow-up) (Table 3). When the models were recalculated with T1 as reference category, there was also a significant increase between T1 and T4 for both POpeak (β = 12.78, SE = 2.99, P < 0.001) and VO_2peak (β = 0.27, SE = 0.06, P < 0.001).

Determinants of the Course of Physical Capacity During Follow-Up

Sex, age, physical capacity at T1, handcycling classification, musculoskeletal pain at T1, exercise stage of change at T1, and exercise self-efficacy at T1 showed no interaction effects with time during follow-up (Table 4). Participants who competed again in the HandbikeBattle event around T4 (n = 18 competitors) showed a significantly different change in physical capacity between T2 and T4 than did participants who did not compete again in the HandbikeBattle event (n = 15 noncompetitors) (Fig. 2). At T4, POpeak was 138 W for competitors *vs.* 111 W for noncompetitors, whereas VO_2peak was 2.18 L/min for competitors *vs.* 1.80 L/min for noncompetitors. Additional multilevel regression analyses for each subgroup showed that the increase in physical capacity between T2 and T4 for the competitors was not significant (POpeak: β = 4.39, SE = 3.49,

TABLE 4. Longitudinal trajectory of physical capacity with interaction effects

	Constant (Reference: T2)	Δ T2–T1	Δ T2–T4	Determinant	(Δ T2–T1) × Determinant	(Δ T2–T4) × Determinant
POpeak, W						
Sex	141.59 (7.64)	−17.93 (3.60)[a]	−4.00 (3.48)	−40.16 (13.30)[a]	8.62 (6.39)	5.20 (6.17)
Age	102.85 (21.49)	0.69 (9.86)	10.03 (9.13)	0.63 (0.51)	−0.38 (0.23)	−0.30 (0.21)
POpeak at T1	14.34 (8.51)	−14.34 (10.53)	1.49 (10.53)	1.01 (0.07)	−0.01 (0.09)	−0.04 (0.09)
Handcycling classification	113.08 (8.99)	−15.19 (4.20)[a]	−7.71 (4.10)	29.80 (12.49)[a]	−0.31 (5.85)	10.12 (5.65)
Musculoskeletal pain	139.80 (10.31)	−19.34 (3.65)[a]	−5.53 (3.56)	−8.98 (15.85)	6.40 (5.78)	1.90 (5.47)
Exercise stage of change	140.75 (20.48)	−33.61 (7.20)[a]	−15.00 (6.45)[a]	−3.90 (22.44)	20.33 (7.80)[a]	12.45 (7.06)
Exercise self-efficacy	−16.00 (81.98)	−42.05 (31.68)	−11.54 (29.82)	4.28 (2.28)	0.72 (0.88)	0.19 (0.83)
HandbikeBattle participation at T4	121.85 (9.94)	−15.18 (4.16)[a]	−10.85 (4.06)[a]	12.15 (13.43)	−0.40 (5.62)	15.24 (5.43)[a]
VO_2peak, L/min						
Sex	2.25 (0.11)	−0.30 (0.07)[a]	−0.08 (0.07)	−0.56 (0.19)[a]	−0.05 (0.12)	0.09 (0.12)
Age	1.83 (0.33)	−0.32 (0.19)	0.15 (0.19)	0.005 (0.008)	−0.000 (0.004)	−0.005 (0.004)
VO_2peak at T1	0.41 (0.17)	−0.41 (0.21)[a]	0.17 (0.21)	0.94 (0.10)[a]	0.06 (0.12)	−0.12 (0.12)
Handcycling classification	1.81 (0.13)	−0.23 (0.08)[a]	−0.05 (0.08)	0.47 (0.18)[a]	−0.18 (0.11)	−0.01 (0.11)
Musculoskeletal pain	2.10 (0.16)	−0.23 (0.08)[a]	−0.08 (0.08)	0.03 (0.24)	−0.18 (0.13)	0.01 (0.12)
Exercise stage of change	2.27 (0.31)	−0.53 (0.17)[a]	−0.24 (0.15)	−0.18 (0.34)	0.28 (0.19)	0.20 (0.17)
Exercise self-efficacy	0.32 (1.27)	−0.68 (0.72)	−0.28 (0.68)	0.05 (0.04)	0.01 (0.02)	0.01 (0.02)
HandbikeBattle participation at T4	1.97 (0.14)	−0.36 (0.08)[a]	−0.17 (0.08)[a]	0.16 (0.19)	0.08 (0.11)	0.22 (0.11)[a]

Data represent regression coefficient (SE). For both outcome parameters (POpeak and VO_2peak), eight separate models were created (one model for each determinant). Each model consisted of the time dummies, one determinant, and the interaction effect between time and determinant. Sex—male/female, reference: male. Handcycling classification—two categories: (0) H1–H3 and (1) H4–H5, reference: H1–H3. Musculoskeletal pain—two categories: (0) no–mild pain and (1) moderate–severe pain, reference: no–mild pain. Exercise stage of change—two categories: (0) 1–3 and (1) 4–5, reference: 1–3. T1 indicates start of the training period; T2, after the training period, before the HandbikeBattle event; and T4, follow-up measurement, 1 yr after the event. For Δ T2–T1, a negative regression coefficient represents an improvement of the dependent variable over time. For Δ T2–T4, a negative regression coefficient represents a deterioration of the dependent variable over time. HandbikeBattle participation represents whether participants were going to participate again in the HandbikeBattle event at the time of their follow-up GXT (0 = no, 1 = yes, reference: no).

[a]Significance with P < 0.05.

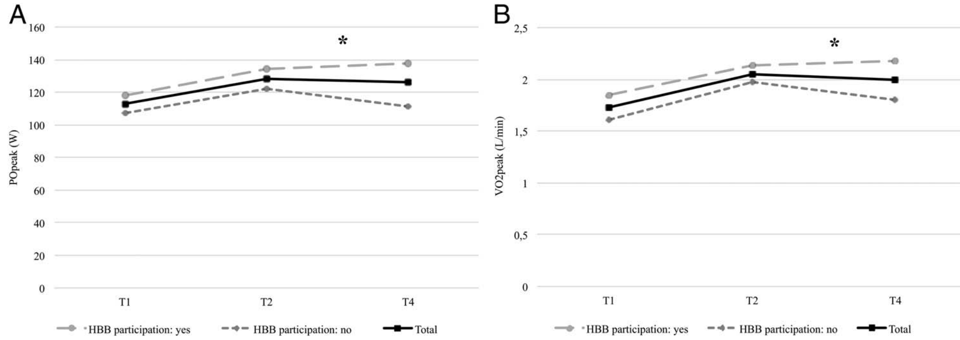

FIGURE 2. Multilevel regression analyses: longitudinal trajectory of physical capacity with interaction effects of HandbikeBattle (HBB) participation at the time of follow-up (T4). T1 indicates start of the training period; T2, after the training period, before the HBB event; and T4, follow-up measurement, 1 yr after the event. A, Regression analysis for POpeak (W). B, Regression analysis for VO_2peak (L/min). * Significant difference in course of physical capacity with $P < 0.05$, between HBB participation yes *vs.* no.

$P = 0.21$; VO_2peak: $\beta = 0.05$, SE = 0.07, $P = 0.50$). However, the decrease in physical capacity between T2 and T4 for the noncompetitors was significant (POpeak: $\beta = -10.87$, SE = 4.20, $P = 0.01$; VO_2peak: $\beta = -0.17$, SE = 0.07, $P = 0.03$). When the models for the noncompetitors were recalculated with T1 as reference category, there was no significant difference between T1 and T4 for POpeak ($\beta = 4.33$, SE = 4.20, $P = 0.30$). VO_2peak was, however, still significantly higher at T4 compared with T1 ($\beta = 0.19$, SE = 0.08, $P = 0.01$). Baseline characteristics were compared between competitors at follow-up and noncompetitors at follow-up (Supplemental Digital Content Table 1, Supplemental Digital Content 2, http://links.lww.com/PHM/B181) similar to the participants *vs.* nonparticipants' analysis. One hundred percent of competitors had a high exercise stage of stage at T1 *vs.* 60% of noncompetitors.

DISCUSSION

Physical capacity showed a significant increase during the training period, and at the group level, this remained stable at 1-yr follow-up. More detailed analyses showed that participants who competed again in the HandbikeBattle showed a slight (nonsignificant) improvement in physical capacity during follow-up, whereas participants who did not compete again in the HandbikeBattle showed a significant decrease.

Physical capacity of the participants at the start (T1; POpeak, 112 ± 37 W; VO_2peak, 1.70 ± 0.48 L/min) was slightly lower than in previous studies in the HandbikeBattle population (POpeak, 119–126 W; VO_2peak, 1.91–2.01 L/min).[5,6,24] The increase in physical capacity (POpeak, 16%; VO_2peak, 22%) during the training period (T1–T2) is comparable with other HandbikeBattle studies and other intervention studies for wheelchair users with a SCI.[6,25]

Long-term follow-up studies on physical capacity or physical activity among wheelchair users are scarce, which is unfortunate as long-term follow-up data are essential to gain knowledge on the effects of exercise and training as well as on determinants of maintenance and relapse in physical activity behavior. In the present study, physical capacity remained stable after 1-yr follow-up for the total group. The only determinant that was associated with the course of physical capacity during follow-up was participating in the HandbikeBattle event again at the time of follow-up. From these results, it is suggested that having a goal to train for seems to be important in exercise maintenance, which is in line with hypotheses in previous research.[10,26,27] The follow-up question would then be why certain participants choose to pursue this goal again, whereas others do not. Having a high physical capacity at the start, and therefore possibly having a more active lifestyle in general, was not associated with the course of physical capacity during follow-up. Again, it was also noted that this was not an extremely fit subgroup of the HandbikeBattle population. In addition, the change in physical capacity during the training period (T1–T2) did not have an interaction effect with participation in the HandbikeBattle during follow-up (Table 4). This indicates that participants who showed the highest gains in physical capacity during the training period are not necessarily the participants competing again in the event next year. Additional baseline comparisons showed that the participants who were not competing again in the HandbikeBattle event during follow-up had a lower exercise stage of change than participants who competed again in the event. This finding could point to the usefulness of exercise stage of change at baseline for long-term exercise maintenance in a rehabilitation population. More research is needed to confirm its usefulness.

Sex, age, handcycling classification, musculoskeletal pain, and exercise self-efficacy were not associated with the course of physical capacity during follow-up. The mean age in the present study was 40 yrs, with range 13–59 yrs; therefore, all participants were in the age category of potentially participating in school or work. The fact that participants with retirement age were not represented could be an explanation for the finding that age was not associated with the course of physical capacity. Compared with a previous study in individuals with SCI that concluded severity of the injury to be associated with leisure time physical activity, the participants in the present study were less severely injured.[11] In the present study, only 9% of participants were classified as H1/H2 (comparable with tetraplegia), whereas in Sweet et al.,[11] 53% had a tetraplegia. It is uncertain why musculoskeletal pain was not associated with long-term physical capacity. A possible explanation is that as a result of exercise, pain is fluctuating (decreasing) over time.[7] Therefore, it could be that musculoskeletal pain at baseline is not a predictor of long-term exercise maintenance, but that longitudinal changes in pain are associated with changes in physical capacity over time. Another explanation is that individuals who have severe (exercise-limiting) pain are not participating in (training for) the HandbikeBattle and therefore the HandbikeBattle participants are a selection with relatively low pain scores.

Participants scored high on exercise stage of change. Eighty-three percent considered themselves as being regularly physically active at the start of the training period. Being regularly active was defined as performing activities like exercise and sports, but also cleaning and household activities for at least 30 mins a day for at least 5 days a week. It could be that the participants were not necessarily involved in sports at the start of the study but were active in their household and daily commute to, for example, work or the supermarket. It was, however, interesting to see that participants within the low category of exercise stage of change showed a larger increase in POpeak during the training period than participants within the high category of exercise stage of change (Table 4). In other words, participants who were already regularly active before the training period showed less improvement in physical capacity than participants who were not (yet) regularly active. This interaction effect was, however, not found during long-term follow-up.

Exercise self-efficacy was not associated with the course of physical capacity during follow-up. Participants had a mean score of 35.8 ± 3.5, which is fairly high but slightly lower than in previous research in a population with subacute SCI in the Act-Active Study (N = 37; median, 37.0; interquartile range, 34.0–39.0)[28] and higher than in another large study in a (inactive) population with long-standing SCI (ALLRISC, N = 268; mean ± SD, 31.4 ± 7.8).[29] In the last study, multivariate regression models showed a significant association between exercise self-efficacy and physical activity but with an explained variance of only 2%.[29] In a home-based exercise intervention study in individuals with SCI, exercise self-efficacy was not associated with physical activity, but a change in exercise self-efficacy was associated with a change in VO_2peak/kg over time.[30]

Limitations

Because of missing data over time and a relatively small sample size, it was not possible to study the dynamic longitudinal character of exercise self-efficacy, exercise stage of change and musculoskeletal pain, and their associations with physical capacity over time. In the present study, self-efficacy and musculoskeletal pain at baseline were not predictive of long-term physical capacity, but it would be interesting to investigate the course of these determinants over time and their association with long-term exercise maintenance.

In addition, the studied population was heterogeneous. The results of the present study are therefore applicable to a general rehabilitation population, but no conclusion could be drawn for a specific diagnosis.

Lastly, in future studies, it would be helpful to obtain complete data on secondary health conditions during the complete trajectory. In the present study, secondary health conditions such as pressure ulcers, urinary tract infections, or respiratory infections were no reason for dropout, but it cannot be ruled out that because of secondary health conditions, several participants were less physically active than they aimed for, at some point during the time of the study.

Implications and Future Studies

Long-term follow-up studies on exercise maintenance in wheelchair users are scarce. The present study shows that physical capacity increases during the training period and that this increase in physical capacity remains stable at 1-yr follow-up. The only determinant that was associated with the course of physical capacity during follow-up was whether participants were going to compete again in the event at the time of follow-up. These results showed that having a goal to train for is a very important determinant for exercise maintenance. The follow-up question would then be why certain participants choose to pursue this goal again, whereas others do not. In addition, goal setting in general is an important factor to focus on as pursuing other (even more challenging) goals could be equally or even more effective. Moreover, other (mediating) factors apart from the goal itself could be the competitive element or the social aspect of training with peers. Future studies should focus on which motivational factors and other determinants play a role in maintaining physical capacity on the long term in wheelchair users.

CONCLUSION

Physical capacity showed an increase during the training period and remained stable at 1-yr follow-up. Participants who competed again in the HandbikeBattle showed a slight (nonsignificant) improvement in physical capacity during follow-up, whereas participants who did not compete again in the HandbikeBattle showed a significant decrease. These results could point at the effectiveness of commitment to a challenge such as the HandbikeBattle to facilitate long-term exercise maintenance.

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