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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

What is the effect of training periodisation on exercise capacity and body composition in people with MS, compared to classic linear training?

Yannick Dominczak
Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :
Prof. dr. Bert OP 'T EIJNDE

COPROMOTOR :
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2018
2019

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Acknowledgement

First of all, we would like to thank our supervisor Prof Dr. Bert Op ‘t Eijnde and especially our co-supervisor Dr. Charly Keytsman. Their feedback, research experience and advice, really contributed in the elaboration of this thesis and guided us through the process.

On top of that we would like to thank Research Centre REVAL of Hasselt University. It was a pleasure to participate in this research project in which we learned to explore the scientific aspect of physiotherapy. Without the possibility to use their infrastructure and facilities, this wouldn’t have been possible.

Even more, we want to thank the participants of this study. Their participation and mentality full of perseverance, drive and kindness during the study provided data for our study and made our investigation possible.

At last, we would like to thank our parents, family ,loved ones and friends for their support during the writing process.

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Research context

Social relevance for research

According to the World Health Organisation (WHO) the global incidence for Multiple Sclerosis (MS) is 30 per 100.000, with the highest incidence in Europe (80 per 100.000). The WHO states that MS is one of the most common neurological disorders causing disability in young adults ([4]). Interventions and treatment described by the WHO for MS include drug treatment, disease-modifying treatment and alternative or complementary approaches. Although the WHO does not describe exercise therapy in particular, existing scientific research suggests that exercise therapy in MS can be considered safe and effective. Moreover, it is said to improve overall fitness ([1; 2; 3]).

Therefore, proper research regarding rehabilitation programs and the improvement of these programs for PwMS might possibly, but not only, improve their quality of life (QoL), activities of daily living (ADL) and overall functioning. Moreover, sufficient research might in the future lead to a revision of the current WHO recommendations regarding exercise therapy in PwMS.

Student Contribution

Research design & methods

The exact design of the study was already determined, as we took part in an ongoing research project. However, we had to think about and create our own design in the first part of the thesis. Although this was not used in the current study, our design showed similarities in terms of inclusion/exclusion and measurements (for ex ample the protocol of the maximal exercise capacity test).

Recruitment and Data-acquisition

Although the research project was ongoing, we helped recruiting participants and acquiring data. We did not perform any data measurements ourselves. However, we did attend some of these measurements, registered their results and supervised some patient training sessions.

Data Analysis

Analysis of data was performed by ourselves. When any problems were experienced, we asked our co-supervisor for advice. However, determining which kind of statistical analysis we needed to use and execution of those tests was done independently.

Writing Process

The writing of this thesis was performed independent from the co-supervisor. However, he did control the writing several times and indicated where adjustments were needed.

References

1. Halabchi, F., Alizadeh, Z., Sahraian, M. A., & Abolhasani, M. (2017). Exercise prescription for patients with multiple sclerosis; potential benefits and practical recommendations. *BMC Neurol, 17*(1), 185. doi:10.1186/s12883-017-0960-9
2. Keytsman, C., Van Noten, P., Spaas, J., Nieste, I., Van Asch, P., & Eijnde, B. O. (2019). Periodized home-based training: A new strategy to improve high intensity exercise therapy adherence in mildly affected patients with Multiple Sclerosis. *Mult Scler Relat Disord, 28*, 91-97. doi:10.1016/j.msard.2018.12.018
3. Kinnett-Hopkins, D., Adamson, B., Rougeau, K., & Motl, R. W. (2017). People with MS are less physically active than healthy controls but as active as those with other chronic diseases: An updated meta-analysis. *Mult Scler Relat Disord, 13*, 38-43. doi:10.1016/j.msard.2017.01.016
4. WHO MS atlas. Consulted on february 8th 2019, retrieved from https://apps.who.int/iris/bitstream/handle/10665/43968/9789241563758_eng.pdf;jsessionid=BF438EF8BEFD104EDAB5FE7B04353FFD?sequence=1

Content

EXERCISE THERAPY IN MULTIPLE SCLEROSIS: TRAINING PERIODIZATION

Research question: What is the effect of training periodization on exercise capacity and body composition in people with MS compared to classic linear training?

Students: Yannick Dominczak and Annelies Meurrens

Promotor: prof. Dr. Bert Op 't Eijnde

Copromotor: Dr. Charly Keytsman

1. Abstract

Background: In people with Multiple Sclerosis (PwMS), exercise is proven to improve various functional parameters. In particular, HIIT is reported to induce superior results in PwMS. However, long-term adherence to HIIT seems rather difficult. Therefore, training periodization could be valuable to optimize rehabilitation in MS. This study reports preliminary results of an ongoing research project.

Objectives: To investigate effects of applying periodization principles in the rehabilitation of PwMS in terms of body composition and exercise capacity, compared to classic linear training.

Participants: 14 PwMS (ten women, four men) participated in this study. They were randomly assigned to a 12-week periodization exercise group ('PER'; n=7) or a 12-week classic linear exercise group ('CLA' ; n=7).

Measurements: Exercise capacity (cardiopulmonary exercise test) and body composition (Dexa) of both groups were assessed at baseline. After completion of the 12-week training program, baseline measurements were reassessed. To compare total exercise commitment and efficiency between training interventions, peak-effort training hours were calculated.

Results: No statistical differences were found for body composition within the PER group (p>0.05). In CLA, total lean mass significantly increased (+0.4%; p=0.043), whilst total fat mass (-14.31%; p=0.043) significantly decreased. No statistical between-group differences were found, except for weight (PER +4.88%; CLA -5.42%, delta p=0.030). In terms of exercise capacity, PER showed a significant improvement in maximal workload (+16.92%; p=0.027) and VO2max (+13.09%, p=0.027). In CLA, a significant increase in maximal workload was found (+14.14%; p=0.026). No significant between group differences for exercise capacity were found. Additionally a difference of 696 peak-effort training hours (55%; PER= 564 hours; CLA=1260 hours) was observed.

Conclusion: Under the present study conditions, 12 weeks of periodized training tended to be at least as effective as classic linear training in PwMS in terms of exercise capacity and body composition. However, PER required reduced time commitment.

2. Introduction

Multiple Sclerosis (MS) is a progressive demyelinating disease of the central nervous system, which is mainly diagnosed in women between the age of thirty and fifty, and affects approximately 13.500 persons in Belgium ([12]).

MS is characterized by a variety of symptoms such as mild to severe motor dysfunctions (including muscle weakness, tremor, spasticity and paralysis), along with impairment of vision, sensory deficits and other clinical manifestations ([1; 4; 10; 11]). These primary symptoms occur mainly because of neurodegeneration and axonal demyelination ([4]). As a result of these symptoms, patients with MS (PwMS) exhibit secondary symptoms, such as decreased aerobic capacity and muscle weakness/atrophy, which have a great influence on the Activities of Daily Living (ADL). Therefore, these patients are in need of strategies to minimize the negative effects of MS. One of these strategies is exercise therapy, which improves physical fitness, muscle strength, fatigue and mobility ([9; 10]) in this population. Exercise therapy in MS is feasible, well-tolerated and may include endurance training, strength training, or both ([2; 4]).

Aerobic endurance training (2–5x/week, 60%–80% HRmax, 10–40 min) in this population is reported to be safe and beneficial for cardiovascular fitness, mood and quality of life (QoL) ([1; 4]) and may include walking, cycling, jogging or rowing. Moreover, resistance training (2-3x/week, 8-15 1RM, 60-80% 1RM) is reported to improve muscle function and fatigue ([4]).

However, recent research ([8; 9; 16]) suggests that high-intensity interval training (HIIT) might lead to superior results. In these studies, HIIT is reported to be safe and seems to be an efficient strategy to improve physical fitness (e.g. exercise capacity) in PwMS.

HIIT is defined as a cardiovascular exercise strategy with alternating short periods of intense anaerobic exercise interspersed by (less-intense) recovery periods. Generally, the short bursts of intense exercise (85%–100% HRmax) last between 1 and 4 minutes, with similar time of work and recovery ([2; 3]).

To this day, the majority of rehabilitation programs consists of continuous moderate intensity exercise ([2]) with a linear progression of intensity, duration and frequency (volume) throughout the entire program. However, this approach may lead to suboptimal training outcomes ([6]).

In athletes, training principles, such as periodization of training, are often successfully applied to optimize outcome and training adaptations. Periodization of training can be described as variations in modalities such as intensity, duration and frequency to optimize training results while preventing overtraining ([13; 14]). This is in contrast to classical linear rehabilitation programs, where these modalities tend to increase linearly.

Periodized training programs incorporate different types of training sessions, such as continuous moderate intensity endurance training (40-85% HR, 30-60 minutes) ([2; 4]) , HIIT (±20 min with alternating 4 to 6 cycles of 80-95%HRmax and recovery) ([2]) or recovery sessions/periods (<30min, <60%HR). Throughout the total program duration, the different modalities vary in cycles, or can be individually tailored around a certain event (e.g. competition, relapse).

In this regard, a recent study explored the application of periodization principles in the rehabilitation of PwMS for the first time ([9]). Here, promising results in terms of exercise capacity (VO2max +5%; workload +11%; time until exhaustion +14%) were observed. However, this study used a home-based training protocol (6 months of training; 8 recurrent 3-week cycles; 3x/week; intensity 60-100% HRmax) and thus needs confirmation in a controlled setting. Furthermore, the potential of such a periodized exercise intervention should be compared to a more conventional, classic exercise intervention.

Therefore, the aim of this study is to investigate the effects of a periodized exercise intervention in the rehabilitation of PwMS compared to a conventional linear (progressive) exercise program.

3. Methods

3.1 Subjects

This paper shows preliminary results of an ongoing study, which, to date, included a total of fourteen PwMS. Recruitment of participants was performed by local advertisements and followed by a written informed consent. The following exclusion criteria were used: Expanded Disability Status Scale (EDSS) score of six and higher and the presence of other chronic diseases. Data collection was performed at Rehabilitation Research Centre of Hasselt University (REVAL). Approval for the study was obtained from the Medical Ethics Committee of the Jessa Hospital in Hasselt (16.111/REVA16.14).

3.2 Study procedure

Design

At baseline, body composition (DEXA scan) was assessed and a maximal graded exercise test (exercise capacity) was conducted. Participants were allocated at random (stratified for VO2max, < or > 30 ml/min/kg), using a randomization tool, to either a twelve week HIIT-oriented periodized training intervention group (PER) or a classic linear program control group (CLA). Each training session was supervised by a physiotherapist, who continuously monitored heart rate of the participant using a Polar (Polar Team®) linked to a tablet. After completion of the 12-week training program, baseline measurements were reassessed. To compare total exercise commitment and efficiency between training interventions, peak-effort training hours were calculated using a previously published formula by Hansen et al 2018 ([5]): (number of prescribed weeks) * (number of prescribed sessions/week) * (prescribed individual sessions duration; min) * (prescribed exercise intensity; %HRpeak). All measurements were performed by blinded assessors. An overview of the design can be found in figure 3.

Classic Linear Control Program

Classic linear training (CLA) consisted of 12 weeks of light-to-moderate intensity, high-volume training on a stationary bicycle. Each week consisted of three 60-minute training sessions. Every session included a five-minute warm-up, 50 minutes of training and a five-minute cool-down. During the first three weeks, training intensity was set at 60-70% of maximal heart rate (HRmax). In weeks four to twelve, progress was made to an intensity of 70-80% HRmax. An overview of this program can be found in Figure 1. At the end of each session, mean heart rate (bpm), mean workload (watt) and perceived rate of exertion (BORG scale 6-20) were registered.

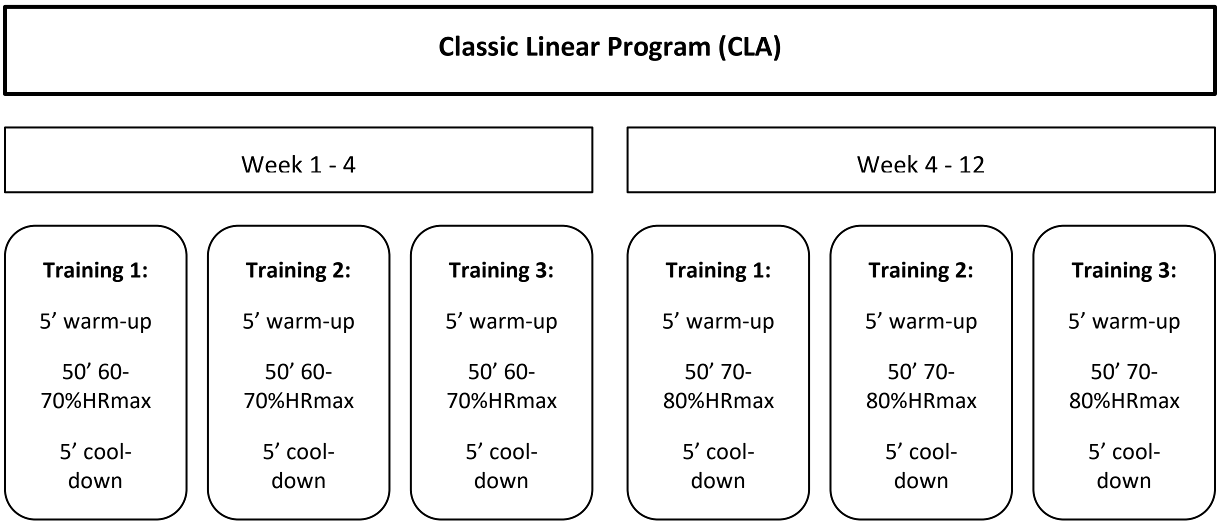

Figure 1

Classic program

Periodized Intervention Program

The periodized intervention program (PER) consisted of four repeating cycles of three weeks of training. The first week of the three-week cycle included three sessions of low intensity volume training as described in the classic control program.

In week two, three HIIT training sessions had to be completed. These sessions included a three-minute warm up, three 20-second all-out sprints interspersed with two minutes of recovery (very low intensity cycling), and a two-minute cool-down. During these sessions, peak heart rate (bpm) and peak workload (Watt) were registered after each sprint. At the end of every session, rating of perceived exertion (BORG) was registered.

Week three involved a recovery week. During this week, only one HIIT session, as described above, was performed. An overview of this program can be found in the figure below (figure 2).

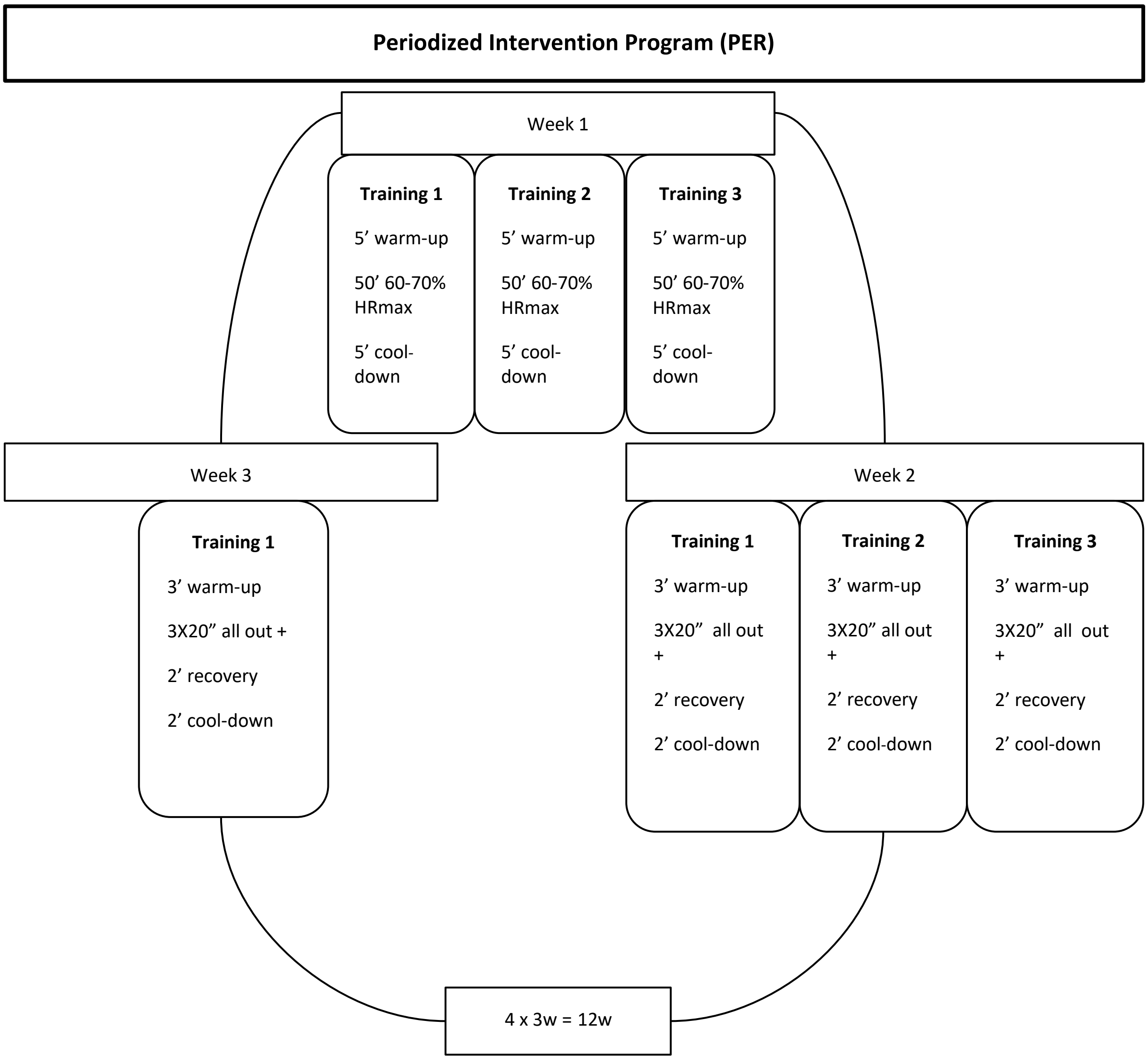

Figure 2

Periodization program

3.3 Measurements

<u>Body Composition</u>

A dual-energy X-ray absorptiometry scan (DEXA) (Hologic Series Delphi-AFan Beam X-ray Bone Densitometer, Vilvoorde, Belgium) was used for the assessment of body composition. From the scans following data was obtained: lean mass (g), fat mass, (g) and fat percentage (%). Total body mass was measured using a calibrated analogue weight scale (Seca®).

Exercise capacity measurements

The maximal exercise test until volitional exhaustion, was performed on an electronically braked cycle ergometer including pulmonary gas–exchange analysis (Jaeger® Oxycon, Erich Jaeger GmbH, Germany). Participants started the test at 20 W (female), or 30W (male) at a cycle frequency of 70 rpm (eBike® Basic, General Electric GmbH, Bitz,Germany). Subsequently, workload increased every minute with 10W (female) or 15W (male). Heart rate was continuously monitored by a 12-lead ECG device, while breath oxygen consumption (VO2), volume of expiration (VE) and respiratory exchange ratio (RER) were collected. At the end of the test, RER was evaluated (≥1.1), to verify for a valid maximal test. Every two minutes, lactate (La) was obtained by blood analysis from the earlobe. Maximal workload (Wmax), maximal heartrate (HRmax) and maximal oxygen consumption (VO2max) with corresponding load, heart rate, minutes and oxygen uptake at exhaustion, were obtained at the end of the test ([8]).

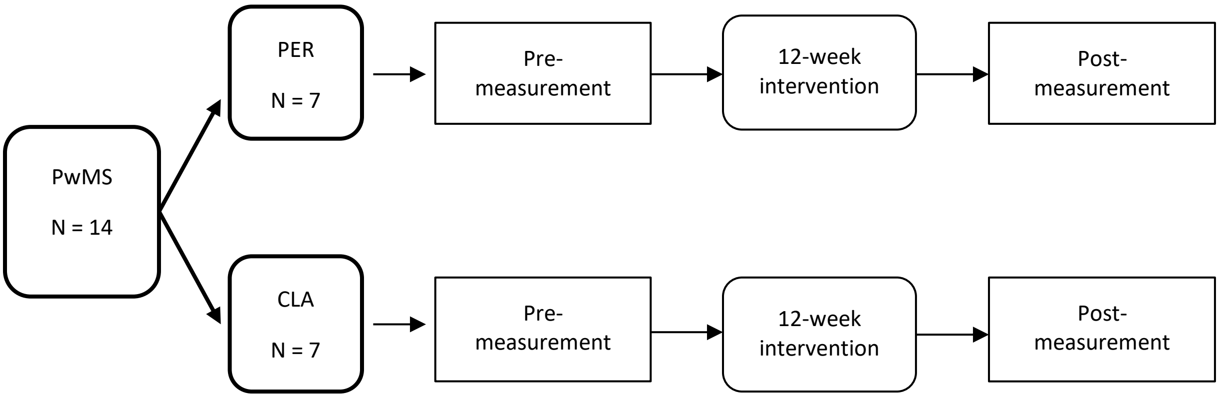

Figure 3

Study design

3.4 Statistical Analysis

Data analysis was performed using IBM SPSS Statistics 25. At first, group differences 'delta' (Post measurements – Pre measurements) were analysed for each parameter and outliers were excluded from all data. After that, differences within groups for pre- and post-intervention were analysed. Because of the small sample size (n<30), parametric as well as non-parametric tests were performed. Within group data were analysed using a Wilcoxon signed ranks test. Between group data were analysed based on pre-post differences (delta), using a Mann-Whitney U test. Results are presented as means ± standard deviations (SD) or mean differences (MD) with confidence intervals (CI). A two tailed significance level of $p < 0.05$ was maintained as threshold during statistical analysis.

4. Results

4.1 Baseline participant and exercise program characteristics

A total of 14 (PER n=7; CLA n=7) PwMS participated in the study so far. Gender did not differ between groups, with each group consisting of five female, and two male participants. Analysis of baseline age (p=0.262) and weight (p=0.294) showed no statistical difference between groups. Baseline characteristics are shown in table 1.

The periodized program included 564 peak training effort hours, while the classic program contained 1260 hours. Peak training effort hours are shown in figure 4.

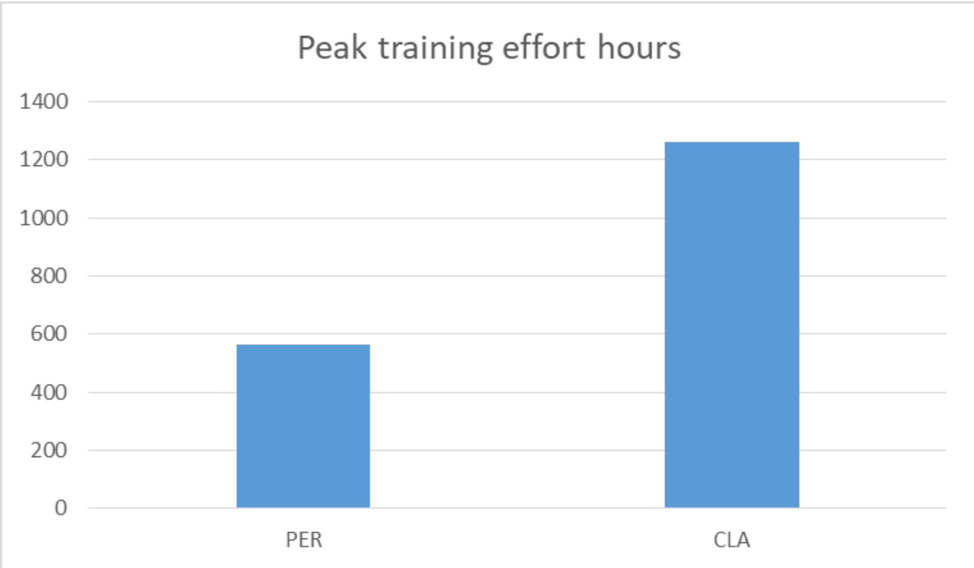

Figure 4

Peak training effort hours

Table 1

Baseline characteristics

	PER	CLA
Age (years)	43.14±10.64	49.14±8.30
Weight (kg)	73.74±12.77	82.40±16.48
Gender (f/m)	5/2	5/2

Data are expressed as means ±SD and represent subject characteristics. Abbreviations: F=female, M=male, PER=periodized group, CLA=classic group

4.2 Body composition

No statistical differences were found for body composition within the PER group (p>0.05). In contrast to PER, total lean mass significantly increased (+0.4%; p=0.043) whilst total fat mass (-14.31%; p=0.043) significantly decreased within the CLA group.

As for between group changes, no statistical differences were found except for weight which was significantly lower in the CLA group (PER +4.88%; CLA -5.42%, delta p=0.030). An overview of these results can be found in table 2.

Table 2. Body composition (Dexa)

	PER		CLA		Delta (p value)
	PRE	POST	PRE	POST	
Weight (kg)	73.74±12.77	77.53±12.23	82.40±16.48	78.17±15.46	0.030[b]
Lean mass (g)	48858.70± 10388.07	50963.76± 1738.97	50226.15± 12848.97	50429.72±14561.35[a]	0.602
Fat mass (g)	22481.20± 8576.06	23325.06± 9053.01	28233.43± 8103.92	24699.20±3973.90[a]	0.117
Fat % (%)	34.20±3.41	34.35±3.57	35.22±6.63	32.96±5.77	0.537

Data are expressed as means ± SD's. 'a': Significant within group changes. 'b': Significant between group changes (delta).

4.3 Exercise capacity measurements

As for within group changes, PER showed a significant improvement in maximal workload (+16.92%; p=0.027) and VO2max (+13.09%, p=0.027). No significant changes for other parameters were detected in this group.

Within the CLA group, a significant increase in maximal workload was found (+14.14%; p=0.026). For all other parameters, no differences were noted.

No significant between group differences for exercise capacity were found.

An overview of these results can be found in table 3.

Table 3. Exercise capacity

	PER		CLA		Delta (p value)
	PRE	POST	PRE	POST	
Maximal workload (W)	139.17± 36.39	167.50± 35.46[a]	141.67± 78.08	165.00±80.93[a]	0.356
VO2 max (ml/kg/min)	27.67± 9.58	31.83± 10.94[a]	25.00±8.98	27.29±8.71	0.466
HR max (bpm)	174.71± 12.66	177.14± 11.73	161.71± 26.18	160.29±22.74	0.481
HR recovery (bpm)	113.40± 24.34	110.40± 19.97	117.86± 16.69	108.57±16.16	0.221
Maximal lactate (mmol/l)	4.52±0.64	5.08±1.62	4.62±0.75	5.05±1.10	0.810
Recovery lactate (mmol/l)	7.80±2.86	8.85±3.54	8.73±3.16	5.22±2.58	0.286
RER	1.16±0.04	1.15±0.06	1.16±0.05	1.12±0.04	0.456

Data are expressed as means ± SD's. 'a': Significant within group changes. No significant between group changes (delta) were found.

5. Discussion

To our knowledge, this study is the first to investigate the effects of a periodized exercise program compared to a classic exercise program in PwMS. Preliminary results of this study show that despite significantly reduced time commitments in PER (55%), both programs seem to induce similar beneficial effects on exercise capacity in MS. However, these results now need confirmation in a larger study population.

Throughout the years, it has been shown that exercise therapy is able to efficiently reduce disease-related impairments and consequences in PwMS ([10]). According to a recent study ([4]), structured exercise reduces the risk for disease-related comorbidities, such as hypertension, obesity, type 2 diabetes, depression and fatigue in PwMS. In addition, HIIT in particular is reported to induce superior results in PwMS in functional parameters such as VO2 peak, maximum tolerated power and heart rate peak ([8; 16; 17]), and is reported to be safe and well-tolerated in this population ([8; 16]). However, long-term adherence to HIIT seems rather difficult, especially in patients with MS ([7]). Therefore, such HIIT interventions should be further optimized in order to be integrated into the rehabilitation of PwMS. Studies ([1; 15]) show that in PwMS most common barriers to regular exercise are: lack of time, fatigue, getting tired by exercising and impairment. Therefore, in order to address such barriers and to optimize training adaptations/outcomes, periodisation of training might be an interesting strategy in PwMS.

Previously, Keytsman et al. (2019) ([9]) explored the application of periodization principles in the rehabilitation of PwMS for the first time. Here, periodized blocks of HIIT were alternated with classic volume training and recovery weeks. Eight identical three-week cycles of periodized home-based bicycle training were used in this intervention. During the first week of the cycle, one session of 1-1.5 hour (75–90% HRmax) and two longer sessions (2-3 hours, 60–80% HRmax) were performed. Week two consisted of three HIIT sessions (3–5 maximal sprints of 60–90 seconds; 90–100% HRmax; rest between intervals 1-3 minutes). In the last week of each cycle, one short HIIT session and one endurance session (2 to 3 hours; 70–90% HRmax) were performed. This 6-month intervention induced significant improvements in body composition (body weight −3%, BMI −3%) and exercise capacity (VO2max + 5%, workload + 11%, time until exhaustion +14%). Although this home-based study showed good therapy adherence (95% training sessions completed) and induced promising results on body composition and exercise capacity, the authors concluded that such a periodized exercise intervention should be investigated in a more controlled setting, and moreover be compared to a classic exercise program.

Therefore, the present study applied periodisation principles in a controlled setting, with supervised one-on-one training sessions. The findings in the present study seem to confirm the beneficial effects of applying periodization principles, with similar to superior improvements in parameters of exercise capacity such as workload (+16.92% vs. + 11%) and VO2max (+13.09% vs. + 5%). However, in contrast to the home-based study, no significant changes in body composition could be found. This might be explained by the duration of the study. The current study only lasted 12 weeks, while the home-based results were extracted from a six month program. Extra repetitions of the cycles and thus a long-term program might be needed to achieve a reduction in body weight.

Furthermore, the periodized exercise program was compared to a more classic, linear exercise intervention where no difference in parameters of exercise capacity were found between both groups. Moreover, no significant differences for body composition were discovered except for weight. This difference might be explained by session volume. Higher volume of training sessions probably results in more caloric expenditure. As a result, more weight reduction was achieved in the CLA group. However apart from weight, it seems that a periodized training program induces at least similar training effects as those of a classic exercise program.

In order to estimate the training efficiency of both programs, a calculation of time commitment was made using a previously published formula by Hansen et al. (2018) ([5]). This formula indicates the volume of peak effort training hours that were necessary to result in the observed end-stage training effects. Interestingly, a difference of 696 hours (55%) in favour of the periodized program (PER= 564 hours; CLA=1260 hours) was observed. As such, under the conditions of the present, ongoing study, we can conclude that the application of periodization principles in the rehabilitation of PwMS seems to result in training effects which are at least similar to those of a classic training program, despite a significantly reduced time commitment. Even more, periodization leads to variation in intensity and duration. This fact, in combination with significant less time commitment, could possibly optimise long-term adherence and thus periodization might result in improved clinical outcomes on long-term. Therefore, applying periodization principles in the rehabilitation of PwMS might lead to further optimisation of conventional exercise interventions.

Limitations of the present study include a small sample size. With a total of 14 participants, the present study has limited power. Therefore, research on larger scale (50+ participants) is needed to confirm the current findings. However, this study is still running and therefore, the findings are preliminary. Furthermore, research to investigate effects of applying periodization principles on longer term is necessary. This study investigated the effects of a 12-week program and showed promising results. However, these findings should now be confirmed in longer term interventions. If periodization effects do not tend to decline and disappear, inclusion in the international guideline of exercise in PwMS might be possible.

6. Conclusion

Preliminary results of this study show that a 12-week periodization program tends to be at least as effective as classic linear training program in PwMS in terms of exercise capacity and body composition. However, less time commitment in PER was found, which might lead to better long-term adherence. These results now need confirmation in a larger study population.

7. References

1. Asano, M., Duquette, P., Andersen, R., Lapierre, Y., & Mayo, N. E. (2013). Exercise barriers and preferences among women and men with multiple sclerosis. *Disabil Rehabil, 35*(5), 353-361. doi:10.3109/09638288.2012.742574
2. Campbell, E., Coulter, E. H., & Paul, L. (2018). High intensity interval training for people with multiple sclerosis: A systematic review. *Mult Scler Relat Disord, 24*, 55-63. doi:10.1016/j.msard.2018.06.005
3. Gillen, J. B., & Gibala, M. J. (2014). Is high-intensity interval training a time-efficient exercise strategy to improve health and fitness? *Appl Physiol Nutr Metab, 39*(3), 409-412. doi:10.1139/apnm-2013-0187
4. Halabchi, F., Alizadeh, Z., Sahraian, M. A., & Abolhasani, M. (2017). Exercise prescription for patients with multiple sclerosis; potential benefits and practical recommendations. *BMC Neurol, 17*(1), 185. doi:10.1186/s12883-017-0960-9
5. Hansen, D., Rovelo Ruiz, G., Doherty, P., Iliou, M. C., Vromen, T., Hinton, S., . . . Dendale, P. (2018). Do clinicians prescribe exercise similarly in patients with different cardiovascular diseases? Findings from the EAPC EXPERT working group survey. *Eur J Prev Cardiol, 25*(7), 682-691. doi:10.1177/2047487318760888
6. Issurin, V. (2008). Block periodization versus traditional training theory: a review. *J Sports Med Phys Fitness, 48*(1), 65-75.
7. Jimenez-Pavon, D., & Lavie, C. J. (2017). High-intensity intermittent training versus moderate-intensity intermittent training: is it a matter of intensity or intermittent efforts? *Br J Sports Med, 51*(18), 1319-1320. doi:10.1136/bjsports-2016-097015
8. Keytsman, C., Hansen, D., Wens, I., & Eijnde, B. O. (2017). Impact of high-intensity concurrent training on cardiovascular risk factors in persons with multiple sclerosis - pilot study. *Disabil Rehabil*, 1-6. doi:10.1080/09638288.2017.1395086
9. Keytsman, C., Van Noten, P., Spaas, J., Nieste, I., Van Asch, P., & Eijnde, B. O. (2019). Periodized home-based training: A new strategy to improve high intensity exercise therapy adherence in mildly affected patients with Multiple Sclerosis. *Mult Scler Relat Disord, 28*, 91-97. doi:10.1016/j.msard.2018.12.018
10. Kinnett-Hopkins, D., Adamson, B., Rougeau, K., & Motl, R. W. (2017). People with MS are less physically active than healthy controls but as active as those with other chronic diseases: An updated meta-analysis. *Mult Scler Relat Disord, 13*, 38-43. doi:10.1016/j.msard.2017.01.016
11. Motl, R. W., Sandroff, B. M., Pilutti, L. A., Klaren, R. E., Baynard, T., & Fernhall, B. (2017). Physical activity, sedentary behavior, and aerobic capacity in persons with multiple sclerosis. *J Neurol Sci, 372*, 342-346. doi:10.1016/j.jns.2016.11.070
12. MS Charcot stichting. Consulted on february 8th 2019, retrieved from https://www.fondation-charcot.org/nl/multiple-sclerose-charcot-stichting
13. Ribeiro, P. A., Boidin, M., Juneau, M., Nigam, A., & Gayda, M. (2017). High-intensity interval training in patients with coronary heart disease: Prescription models and perspectives. *Ann Phys Rehabil Med, 60*(1), 50-57. doi:10.1016/j.rehab.2016.04.004
14. Strohacker, K., Fazzino, D., Breslin, W. L., & Xu, X. (2015). The use of periodization in exercise prescriptions for inactive adults: A systematic review. *Prev Med Rep, 2*, 385-396. doi:10.1016/j.pmedr.2015.04.023
15. Stroud, N., Minahan, C., & Sabapathy, S. (2009). The perceived benefits and barriers to exercise participation in persons with multiple sclerosis. *Disabil Rehabil, 31*(26), 2216-2222. doi:10.3109/09638280902980928

16. Wens, I., Dalgas, U., Vandenabeele, F., Grevendonk, L., Verboven, K., Hansen, D., & Eijnde, B. O. (2015). High Intensity Exercise in Multiple Sclerosis: Effects on Muscle Contractile Characteristics and Exercise Capacity, a Randomised Controlled Trial. *PLoS One, 10*(9), e0133697. doi:10.1371/journal.pone.0133697
17. Zaenker, P., Favret, F., Lonsdorfer, E., Muff, G., de Seze, J., & Isner-Horobeti, M. E. (2018). High-intensity interval training combined with resistance training improves physiological capacities, strength and quality of life in multiple sclerosis patients: a pilot study. *Eur J Phys Rehabil Med, 54*(1), 58-67. doi:10.23736/S1973-9087.17.04637-8

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KNOWLEDGE IN ACTION

INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
20/12/'18	Data + statistiek Planning verdere aanpak	Promotor: Copromotor/Begeleider: [signature] Student(e): [signature] Student(e):
21/01/'19	Statistiek	Promotor: Copromotor/Begeleider: [signature] Student(e): [signature] Student(e):
08/02/'19	Statistiek	Promotor: Copromotor/Begeleider: [signature] Student(e): [signature] Student(e):
20/02/'19	Statistiek	Promotor: Copromotor/Begeleider: [signature] Student(e): [signature] Student(e):
09/04/'19	Resultaten + discussie	Promotor: Copromotor/Begeleider: [signature] Student(e): [signature] Student(e):
10/05/'19	Discussie	Promotor: Copromotor/Begeleider: [signature] Student(e): [signature] Student(e):
24/05/'19	Ondertekenen toestemming	Promotor: Copromotor/Begeleider: [signature] Student(e): [signature] Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):
		Promotor: Copromotor/Begeleider: Student(e): Student(e):

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Yannick Dominczak	**Datum:** 24/05/2019
Titel Masterproef: What is the effect of training periodization on exercise capacity and body composition in people with MS, compared to classic linear training?	

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	**NVT**	**1**	**2**	**3**	**4**	**5**
Opstelling onderzoeksvraag	O	O	O	O	X	O
Methodologische uitwerking	O	O	O	O	X	O
Data acquisitie	X	O	O	O	O	O
Data management	X	O	O	O	O	O
Dataverwerking/Statistiek	O	O	O	X	O	O
Rapportage	O	O	O	O	X	O

2) Niet-bindend advies: Student(e) krijgt toelating/~~geen toelating~~ (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/~~niet~~ (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag wel/~~niet~~ (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)
24/05/2019 [signature]	24/05/2019 In opdracht promotor Bert Op't Eijnde [signature]	[signature]