A systematic review of the effectiveness of aerobic exercise interventions for children with cerebral palsy

An AACPDM evidence report

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Abstract

The aim of this review was to assess the evidence regarding the effectiveness of aerobic training interventions for children with cerebral palsy. The target population included children with cerebral palsy of any severity, aged 2 to 17 years old. The following databases were searched for English studies from 1960 to the present: MEDLINE, EMBASE, CINAHL, Pascal, Cochrane Library, CSA Neuroscience Abstracts, PEDro and Sport Discus Search terms included cerebral palsy, athetoid, ataxic, spastic diplegia, hemiplegia, quadriplegia, aerobic, exercise, training, physical activity, aquatic/water/pool therapy, and continuous exercise. The American Academy of Cerebral Palsy and Developmental Medicine (AACPDM) systematic review guidelines were used to format the review. One thousand four hundred and eighty nine articles were identified and examined for the stated inclusion and exclusion criteria. Thirteen articles met the criteria for inclusion. The evidence suggests that aerobic exercise with children with cerebral palsy can improve physiological outcomes, but the influence of these changes on outcomes representing activity and participation in unknown. Future research needs improved methodological rigour in order to determine a specific set of exercise guidelines and safety considerations.

The AACPDM has undertaken the development of systematic reviews to summarize the literature about specific intervention strategies used to assist children with developmental disabilities. These reviews are not best practice documents or practice guidelines, but rather they gather and present the best evidence – for and against – the effectiveness of an intervention. Their goal is to present the evidence about interventions in an organized fashion to identify gaps in evidence and help address new research that is needed. The Academy is neither endorsing nor disapproving of an intervention in these reviews. Every effort has been made to assure that AACPDM systematic reviews are free from real or perceived bias. Details of the disclosure and consensus process for AACPDM outcomes reports can be viewed at www.AACPDM.org. Nevertheless, the data in an AACPDM Systematic Review can be interpreted differently, depending on people's perspectives. Please consider the conclusions presented carefully.

Background

Therapeutic programs for adults and children with disabilities are increasingly incorporating a fitness component into intervention strategies. The benefits of aerobic exercise for persons with disabilities include increased cardiovascular capacity and endurance, weight management and lower blood lipid levels, preservation of bone mass and overall maintenance of function.[2] In addition, the opportunity for persons with disabilities to participate in community aerobic fitness programs allows them to take responsibility for their own health and fitness. People with a physical disability have identified numerous barriers to participation in physical activities including physical accessibility to exercise facilities, shortage of adapted exercise equipment, inability to pay for a fitness membership and a lack of knowledge in the fitness and exercise professions about how to appropriately design an exercise program for specific disabilities.[3] Health counseling about the importance of physical activity and its accessibility for persons with disabilities is minimal.[3]

Historically, exercise programs that included aerobic or muscle strengthening components were often contraindicated for persons with cerebral palsy because of the concern that increased effort and exertion during exercise would result in increased muscle tone, a decrease in range of motion, and/or an overall decrease in function.[4] Concerns about the safety of progressive resisted muscle strengthening for children with cerebral palsy have been negated by recent studies that demonstrate no increase in spasticity and no loss of range of motion following a resistance training program.[4-6] While strength training is now recognized as an effective intervention for improving muscle strength with children with cerebral palsy[4], the efficacy of aerobic exercise as a safe and beneficial intervention option for children with cerebral palsy has not been reviewed in the literature. The purpose of this review is to review the evidence for the effectiveness of aerobic exercise interventions for children with cerebral palsy.

Method

OPERATIONAL DEFINITION AND INCLUSION CRITERIA

Aerobic exercise was defined as any activity that increases heart rate or proposes to increase heart rate to exact physiological change. The outcomes evaluated represented more than just physiological measures such as 6 minute walk distance or gait efficiency. All outcomes included in the studies were documented. Studies with a sample that included children aged 2 to 17 years with any severity of cerebral palsy diagnosis were eligible for inclusion. At least 50% of subjects in the study sample had to have a diagnosis of cerebral palsy, or the results of the subjects with cerebral palsy must be distinguishable from children with other diagnoses and analyzed separately.

LITERATURE SEARCH

A medical librarian assisted with the search strategy. The following databases were searched in English only from 1960 to 2006: CINAHL (297 studies), Cochrane Library (65), CSA Neuroscience Abstracts (1), EMBASE (464), MEDLINE (372), Pascal (64), The Physiotherapy Evidence Database (PEDro) (3), and Sport Discus (223). The search terms used for the target population were: cerebral palsy, athetoid, ataxic, spastic diplegia, and quadriplegia. The intervention search terms were: aerobic, exercise, training, physical activity, aquatic/water/pool therapy, and continuous exercise. A specific pediatric search, ARCHE (Alberta Research Centre Health Evidence), was also applied to the OVID search engines. The initial search yielded 1489 articles; 1205 articles were excluded based on the inappropriateness of their titles. The remaining 284 abstracts were read independently by two reviewers and conflicts were resolved by a third reader if required. Two-hundred seventy-one articles were excluded for one or more of the following reasons: 1) lack of aerobic exercise intervention, 2) no reported aerobic fitness outcomes, 3) use of a one-time exercise protocol, 4) the population did not match the inclusion criteria, or 5) review articles. Thirteen articles met the inclusion criteria.

ORGANIZATION OF EVIDENCE

Outcome measures were classified according to the components of the International Classification of Functioning, Disability and Health (ICF)[7] as presented in Table I. Studies were classified using a hierarchy of research design rigour (Table II). Level I studies produce results from which definitive conclusions can be made. Level II thru level IV studies report progressively less credible evidence from which only cautious conclusions can be drawn. No definite conclusions can be made from level V evidence.

Table III summarizes the 13 studies reviewed. Two small, randomized controlled trials had control groups that received the same intervention as the experimental group but at a reduced frequency.[8,9] One cohort study used the subjects that dropped out or did not begin training as the control group.[10] Five studies compared the results of a pre-test/post-test in a single group with no control using a variety of aerobic exercise programs ranging from games to bicycle ergometry.[11-15] The remaining studies consisted of 2 case studies [16,17] and 3 single subject design studies.[18-20]

Tables IV and V include only evidence from the studies that received a level of evidence rating of level III or higher. Level IV and V studies are not included in the final evidence tables because of threats to internal validity due to weak study design. In addition, the level of evidence of single subject design studies cannot be rated within the levels defined for group studies. Table IV provides the conduct ratings of the studies rated as level III evidence and higher. The conduct rating provides an assessment of the quality of the study based on the score from the seven evaluative questions under Table IV. Each study was rated by two independent reviewers and a third reader was available to resolve conflict and determine the final rating if necessary.

Table V summarizes the outcomes of interest, the measures used to quantify the outcomes, the ICF components of health represented by the outcome measures used, and the statistical results. No study reported power calculations and thus studies reporting a 'not reported' (nr) or 'not significant' (ns) result may not have enough power to detect true differences between groups.

Analysis and discussion of the evidence

1. WHAT EVIDENCE EXISTS ABOUT THE EFFECTS OF AEROBIC EXERCISE ON MEASURES REPRESENTING THE COMPONENTS OF BODY FUNCTION AND STRUCTURE?

All outcomes measured in the studies reported in Tables IV and V represent the components of body structure and function. All three studies evaluated physiological variables related to aerobic fitness, two reported body composition[9,10] and one study measured grip strength and mechanical efficiency[10] but these two outcomes were not analyzed statistically.

Aerobic fitness.

Significant improvement in aerobic fitness following training was reported in all three studies. Different outcome measures were used to determine change in aerobic fitness, including heart rate (HR) during sub-maximal and maximal tests,[10] VO_{2peak} and VO_{2max}[9,10] and the relationship between VO_2 and workload and VO_2 and heart rate.[8]

The level II study by van den Berg-Emons et al. demonstrated an improvement in aerobic fitness following two, 9-month, “high intensity” training sessions 45 minutes in duration, four times a week which involved cycling, wheelchair skills, running, swimming and mat exercises.[9] In contrast, Dresen et al. (level II) showed a significant decrease in VO_2/workload after a 10-week training program that consisted of regular physical education activities (judo, swimming and games) for a total of two hours per week.[8] The only difference between the control and experimental groups in this study was that the latter simply received undefined “active encouragement” from the instructor. Van den Berg-Emons et al. found a significant increase in peak aerobic power after training.[9] This same increase was not observed following a two month rest period, suggesting that although children with cerebral palsy are able to improve their level of aerobic fitness, it may not be maintained over time if the exercise level is not maintained.

Body composition.

Both van den Berg-Emons et al.[9] (level II) and Bar-Or et al.[10] (level III) used the measures of height, weight and skinfolds to report anthropometric variables. Bar-Or et al.[10]

reported significant change in the height variable, in both the control and exercise groups, while van den Berg-Emons et al.[9] measured fat mass (skinfolds) and showed a significant increase in the control group.

2. WHAT EVIDENCE EXISTS ABOUT THE EFFECTS OF AEROBIC EXERCISE ON MEASURES REPRESENTING THE COMPONENTS OF ACTIVITY AND PARTICIPATION?

None of the studies in the evidence tables reported outcomes representing the ICF components of activity and participation.

3. WHAT KINDS AND MAGNITUDE OF COMPLICATIONS HAVE BEEN DOCUMENTED?

Safety concerns were not discussed in any articles, including studies categorized as Level IV and V. There were no reports of increased spasticity, medical problems or the occurrence of musculoskeletal trauma in any of the studies reviewed. Evaluation of adverse effects such as fatigue was not reported.

4. WHAT IS THE STRENGTH OF THE EVIDENCE?

The results of the three level II-III studies all suggest that aerobic exercise intervention can improve physiological outcomes in children with cerebral palsy. However, the total number of subjects in the review is only 58, and the largest single sample was 26 participants.[10] As described in Table III, most samples were extremely variable both in the ages of the children and their physical abilities. Given the small sample size, the heterogeneity of both the samples and inventions and the poor conduct ratings received by the Level II and III studies (Table IV), it is difficult to identify specific components of aerobic intervention that are most effective.

The age range of participants among the studies ranged from 7 to 22 years. The physical abilities of the children within the same study ranged from mild to severe diplegia and hemiplegia, and ability levels included ambulatory and non-ambulatory. This heterogeneity of age and motor abilities makes it difficult to discern the extent to which each subject was able to participate in an exercise program. Children with differing motor abilities and different ages may respond differently to aerobic exercise intervention. The samples in the studies were all too small to allow for subgroup analyses.

Most of the interventions are non-replicable because of lack of detail provided. Intervention activities ranged from game activities in a physical education setting with "active encouragement"[8] to more specific aerobic exercise such as cycling, wheelchair skills and running. There was no description as to whether the activity was continuous or non-continuous or what equipment/intervention adaptations had to be made for the non-ambulatory participants. Exercise parameters varied among the studies; intensity of exercise varied from inconsistent monitoring of 160 beats per minute[8] to subjective opinions based on investigators' observations during game play.[10] Frequency varied from a total of 2-6 hours a week spread over a range of 2-4 exercise sessions a week. Duration of the intervention programs varied from 10 weeks to 18 months.[8,9] Standardized guidelines for frequency, duration, intensity and type of exercise necessary to impose physiological change cannot be extracted from this body of literature.

The measures used in the level I to III studies focused on the outcomes of body structure and function. All three studies used oxygen consumption (VO_2), heart rate (HR) or the relationship between VO_2 and HR to detect change in aerobic fitness, but these measures were not standard across or even within these studies. For example, Bar-Or et al.[10] used both a sub-maximal and a maximal VO_2 test, whereas Dresen et al.[8] used only sub-maximal VO_2 testing.

Although both groups of authors reported an improvement in oxygen consumption, they are reporting different outcomes (VO_{2max} vs. sub-maximal VO_2 to workload ratios) and therefore do not allow for the discussion of a trend across studies. No studies evaluated the relationship between improvement of aerobic fitness at a physiological level and improvement of outcomes representing the ICF components of activity and participation. Therapists are interested in optimizing the functional abilities of children with cerebral palsy and future studies need to systematically evaluate the relationship of outcomes representing components of body function and structure and activity and participation. For example, does an increase in VO_{2max} result in improved walking endurance or mobility in school?

Summary and directions for future research.

The limited evidence available suggests that children with cerebral palsy who participate in an aerobic exercise training program demonstrate improvements in physiological measures of aerobic fitness. However the body of research has methodological limitations and is based on a small sample size.

The current emphasis on functional goals and community exercise opportunities for children with cerebral palsy may have moved research about the effects of aerobic exercise too rapidly from controlled laboratory settings to community exercise programs. The paucity of controlled laboratory research suggests that more information is needed from laboratory settings to establish the efficacy of aerobic exercise models using exercise regimes with different intensity, frequency and duration parameters. When these parameters are better established and understood, then the effectiveness of the programs in community setting could be systematically evaluated. However, because of the interest in community fitness programs for children with cerebral palsy, it is doubtful that the community programs will wait until the efficacy information from laboratory settings is available. If the research in the two different settings continues to develop simultaneously, it would be valuable to collect similar information from both settings for comparison. By using the same cadre of measures representing all components of the ICF in both controlled laboratory condition and community settings, future research endeavors can begin to systematically evaluate the relationships across the ICF components.

Although the study designs of levels IV and V evidence inherently limit the confidence that can be placed in these results, it is interesting to note that measures that target outcomes within the ICF components of activity and participation were used in some of these studies. Several studies reported an improvement in gait efficiency [16,17] and in the distance walked during a 6-minute walk test [19]. A few authors reported improvement in psychological variables such as self-perception of physical appearance [11], athletic competence and self-worth using either the Self Perception Profile for Adolescents (SPPA) or College students (SPPC).[12,20] These types of outcomes need to be incorporated in studies of more rigorous research design. No complications or safety concerns were reported in any of the Level IV and V studies.

The finding that children with cerebral palsy are able to train to elicit physiological change is a positive outcome that should serve as a catalyst for future well-designed studies to establish safe, effective, and specific exercise guidelines for children of different ages and ability levels.

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Table I

Classification of Outcomes

ICF Component	Definition
Body Function	Body functions are the physiological functions of body systems including psychosocial functions
Body Structure	Body structures are anatomical parts of the body such as organs, limbs, and their components
Activity	Activity is the execution of a task or action by an individual
Participation	Participation is involvement in a life situation
Context/Environmental Factors	Environmental factors make up the physical, social and attitudinal environment in which people live and conduct their lives

Table II

Levels of Evidence

Level	Intervention (Group) studies
I	Systematic Review of randomized controlled trials (RCTs) Large RCTs (with narrow confidence intervals) (n >100)
II	Smaller RCTs (with wider confidence intervals) (n <100) Systematic Reviews of cohort studies “Outcomes research” (very large ecologic studies)
III	Cohort studies (must have concurrent control group) Systematic Reviews of Case Control Studies
IV	Case series Cohort study without concurrent control group (e.g. with historical control group) Case-control study
V	Expert Opinion Case Study or report Bench research Expert opinion based on theory or physiologic research Common sense/anecdotes

Table III
Summary of Studies: Interventions and Participants

Study	Level of Evidence/ Research Design	Intervention	Control Intervention	Population	Total n	Ages
1967 Lundberg et al.	IV Pre-test/ Post-test with no control group	Continuous large muscle group exercise (running, jumping, parallel bars): 30 min, 2x/wk Duration: 6 wk	None	CP: 3 hemiplegia, 3 diplegia, 3 tetraplegia, 4 athetosis, 1 ataxia	14	15-20y
1970 Berg	IV Pre-test/ Post-test with no control group	Bicycle ergometer at varying intensities: 20 min, 3x/wk Duration: 1.5- 16 mo	None	CP: 12 spastic diplegia or tetraplegia, 10 dyskinetic disturbances	22	7-25y
1970 Lundberg & Pernow	IV Pre-test/Post-test with no control group	Continuous large muscle exercise (running, jumping, parallel bars, dumbbells, medicine balls, pulleys): 30 min, 2x/wk Duration: 6 wk	None	CP: 3 diplegia, 3 athetosis, 1 hemiplegia, 1 ataxia, 1 post-traumatic spastic hemiplegia	9	15-25y
1976 Bar-Or et al.	III-W (1/7) Cohort Study	Combination of group and individual games	9 children with cerebral palsy that did not begin or	CP. 26 Spastic diplegia with 2 subjects with a mix of	26	15-22y

		(table tennis, shuffleboard, bowling) and mat exercises: 2hr/d, 2d/wk Duration: 12 mo	stopped training within first 2 mo	spasticity and athetosis. All ambulatory to varying degrees		
1985 Dresen et al.	II-W (3/7) Small RCT	Regular physical education classes (judo, swimming and games): 3x/wk for total of 2hr/wk Duration: 10 wk	As intervention without active encouragement.	CP: 6 spastic hemiplegia, 3 spastic diplegia, 1 dwarf growth, 1 cerebellar ataxia. 4 of 11 were being treated for epilepsy	12; EXP= 6 CON=5 1 drop-out	8-14y
1990 Rintala et al.	Single Subject Design	Rotation through activities targeting static and dynamic balance, physical fitness and catching and throwing skills: 1hr/d, 2 d/wk for a total of 30 sessions. Duration: 4 mo	None	CP: 8 with either hemiplegia or diplegia, All ambulatory	8	7-11y
1998 van den Berg-Emons et al.	II-W (2/7) Small RCT	a) First year Intervention: Group aerobic exercise program (cycling, wheelchair skills, running, swimming, flying saucer, mat exercises): 45 min,	Regular school physical education and individual physiotherapy sessions.	CP: 16 diplegia, 4 tetraplegia. 10 ambulatory, 10 used wheelchair	20 a) EXP= 10 CON=10 b) EXP=17 CON=10	7-13y

		4x/wk in addition to regular PE and PT Duration: 9 mo b) Second Year Intervention: As in a) minus swimming and isokinetic strengthening: 45 min, 2x/wk plus regular PE and PT Duration: 9 mo				
1998 Wiepert & Lewis	V Case Study	PT led activities including ball play, step-ups, prolonged walking, tricycle riding: 1hr/d, 2d/wk Duration: 6 wk	None	1 child with hemiparetic CP	1	3y
1999 Darrah et al.	IV Pre-test/Post-test with no control group	Circuit training program including aerobics, strengthening, flexibility: 70-90min, 3x/wk Duration: 10 wk	None	CP: 13 hemiplegia, 5 diplegia, 2 quadraplegia, 2 ataxia, 1 dystonia. 2 non-ambulatory, 1 used a walking stick, 20 independent ambulators	23	11-20y
2002 Shinohara et al.	IV Pre-test/ Post-test with no control group	Children trained at anaerobic threshold (AT) point on either arm or leg cycle ergometer (as able):	None	11 CP. All ambulatory to varying degrees.	11	13.3-15.8y

		20 min, 1.8 d/wk Duration: 6 to 20 wk				
2004 Mulligan et al.	Single Subject Design	Cardiovascular and strength conditioning program at outpatient facility: 1d/wk, 3 additional strength sessions at home and encouragement to increase daily physical activity Duration: 6 wk	None	CP: 1 spastic diplegia	1	13y
2005 Fragala-Pinkham et al.	IV Case Report	a) Group fitness program (movement to music, parachute games, obstacle courses, games, riding bicycles, strength training): 60-70min, 2x/wk Duration: 14 wk b) Non-simultaneous home exercise program: written instructions and video taped aerobics and	None	CP: 1 hemiplegia, 3 spastic diplegia, Non- CP: 1 anoxic brain injury, 2 developmental coordination disorders, 1 pervasive developmental disorder, 1 developmental delay	9	5-9y

		strengthening activities: 2x/wk Duration: 3 mo				
2005 Schlough et al.	Single Subject design	Cardiovascular exercise machines: treadmill, elliptical, recumbent stepper: 2-5min/d which was progressed, 3x/wk Duration: 6 wk	None	CP: 3 with either spastic hemiplegia or diplegia. All ambulatory	3	17-20y

min-minute; wk-week(s); CP-cerebral palsy; y-year(s); mo-month(s); hr-hour(s); d-day(s); EXP-experimental; CON-control; PE-physical education; PT-physical therapy

Table IV

Conduct of Study

Study	Level/Quality	1	2	3	4	5	6	7
1976 Bar-Or et al.	III strong	Yes	Yes	No	Yes	Yes	Yes	Yes
1985 Dresen et al.	IImoderate	No	Yes	No	Yes	Yes	No	Yes
1998 van den Berg-Emons et al.	IImoderate	Yes	Yes	No	Yes	Yes	No	Yes

Conduct of a study was rated as Strong (score 7 or 6), Moderate (score 5 or 4), or Weak (score <3)

1. Were inclusion and exclusion criteria of the study population well described and followed?
2. Was the intervention well described and was there adherence to the intervention assignment? For 2-group designs was the control exposure also well described?
3. Were the measures used clearly described, valid and reliable for measuring the outcomes of interest?
4. Was the outcome assessor unaware of the intervention status of the participants (i.e. were there blind assessments)?
5. Did the authors conduct and report appropriate statistical evaluation including power calculations?
6. Were dropouts/loss to follow-up reported and less than 20%? For 2-group designs, were dropouts balanced?
7. Considering the potential within the study design, were appropriate methods for controlling confounding variables and limiting potential biases used?

Table V

Summary of Studies: Outcomes, Measures, and Results

Study	Outcome of Interest	Measure	Components of Health		
			Body Structure(s)/Function	Activities & Participation	Contextual Factors
1976 Bar-Or et al.	Body Composition Aerobic Fitness Grip Strength Mechanical Efficiency Submaximal Heart Rate	Height Weight Skinfolds Submaximal test Maximal test (peak VO_2) Handheld dynamometer Submaximal test Bipolar ECG	nr nr nr $p<0.01$ EXP (CP) $p<0.05$ EXP (CP) nr nr $p<0.01$ EXP (CP)		
1985 Dresen et al.	VO_2/ WL (POST) VO_2/WL (FOLLOW-UP) VO_2/ HR Exercise Intensity (HR $\geq$ 160bpm)	Submaximal test Submaximal test Submaximal test Telemetric transmitters, HR memories, chest cables	$p<0.05$ EXP $p<0.05$ EXP ns $p<0.05$		
1998 van den Berg-Emons et al. *	Body Composition Level of Daily Physical Activity (PA) Peak Aerobic Power	Height Weight Skinfolds Fat mass TEE/ SMR and/or TEE/RMR Cycling test	nr nr nr $p<0.05$ CON (year 1) ns (year 1), $p<0.05$ EXP (year 2) $p<0.01$ EXP (year 1), $p<0.01$ EXP (year 2) but no difference between		

	Peak Anaerobic Power Isokinetic Strength	Cycling test Cybex II	CON and EXP (year 2) ns $p<0.05$ EXP (year 2) for most affected leg		

VO_2-oxygen uptake; ECG-electrocardiograph; nr-not reported; EXP-experimental; CP-cerebral palsy; VO_2/WL-oxygen uptake to workload ratio; VO_2 /HR-oxygen uptake to heart rate ratio; HR-heart rate; bpm-beats per minute; ns-not statistically significant; TEE/SMR-total energy expenditure/ sleeping metabolic rate; TEE/RMR-total energy expenditure/ resting metabolic rate; CON-control

*Results:
The van den Berg-Emons et al. study was carried out over 2 years. The experimental group in the first year consisted of 10 subjects that participated in 4, 45 min. exercise sessions 4 times a week in addition to regular physical education and individual physical therapy (PT) sessions while the control group solely received the physical education classes and individual PT. At 9 months follow-up testing, physical activity level increased by 16% but was not statistically significant ($p<0.07$) and was not different from the control group. Fat mass (FM) continued to increase over the 9-month school term in the CON ($p<0.05$ at 9 months follow-up) with no change in FM in experimental group. Peak aerobic power increased by 35% in EXP and was significantly greater than CON at 9 months ($p<0.01$). Anaerobic power increased in CON ($p<0.05$) and a similar trend was demonstrated in EXP ($p<0.06$) with no difference between groups, suggesting the change may be a result of maturation of the subjects.
Following the summer, holidays peak aerobic power decreased significantly in the EXP group by 17% ($p<0.01$).
In the second year of the study, the original EXP group and the original CON group both participated in 2, 45 min exercise sessions a week in addition to physical education class and individual PT and were labeled as EXP_{2xtot} and EXP_{2x}, respectively. The groups were also compared to the original CON. Following the second year of training, there was no significant increase in PA in either EXP_{2xtot}, EXP_{2x} and the change in PA was not different from the change that occurred in CON suggesting that 2 additional exercise sessions/ week did not increase PA level more than the change in CON with only physical education classes and individual PT. Fat mass was significantly lower in the children who trained 4 times a week (EXP) from the first year of study, compared to those who trained only twice a week (EXP_{2x}) ($p<0.05$). There was a significant increase in peak aerobic power in EXP_{2x} ($p<0.01$) at 9 months but the difference between EXP_{2x} and CON was not significant. Isokinetic muscle strength increased in the most affected leg in EXP_{2xtot} at 9 months ($p<0.05$).