Assessment of the selected physiological effects of Nordic Walking performed as a part of a physical exercise program during the second phase of rehabilitation after a myocardial infarction

Ocena niektórych fizjologicznych efektów zastosowania Nordic Walking jako uzupełniającego elementu ćwiczeń fizycznych w drugim etapie rehabilitacji po zawale serca

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Key words
acute coronary syndrome, cardiac rehabilitation, exercise training, exercise tolerance

Abstract
Background: Walks and marches are a simple yet effective forms of physical activity, commonly used in the cardiac rehabilitation. It has been recommended recently to combine march training with exercises involving upper limbs. One of the most popular methods is Nordic Walking, during which special poles are used to increase the work of upper part of the body. The aim of the study was to assess the influence of Nordic Walking on the improvement in exercise tolerance and physical performance in patients rehabilitated after a myocardial infarction.
Methods: The study population consisted of 30 patients hospitalized in a cardiac rehabilitation ward 14 to 28 days after myocardial infarction. On admission and after completing the rehabilitation program patients performed an exercise test following the modified Bruce protocol, a six-minute walk test and a test assessing physical performance (Fullerton test). 10 subjects were assigned to a control group, which followed a standard training program, and 20 patients to a group which additionally performed a march training using the Nordic Walking method 5 times a week. Each session of the march training lasted 40 minutes and consisted of a 3-kilometer walk interrupted by breaks during which respiratory and stretching exercises were performed. During the march and exercises patients used special poles for Nordic Walking.
Results: Exercise tolerance improved in both study groups. However, the increase in the exercise tolerance was greater in the group performing Nordic Walking than in the control group (30% vs. 14%, respectively; $P < 0.05$). The rate-pressure product during the exercise test increased significantly only in the group performing Nordic Walking (from $18.2 \times 10^3 \pm 3.3 \times 10^3$ to $20.7 \times 10^3 \pm 4.4 \times 10^3$; $P < 0.05$). The improvement in the results of the six-minute walk test was greater in the group performing Nordic Walking (22% in comparison with 17% in the control group; $P < 0.05$). The results of the test assessing physical performance (Fullerton test) improved in both study groups.
Conclusion: The results of this preliminary study indicate that march training using the Nordic Walking method effectively increases exercise tolerance and physical fitness in patients after myocardial infarction. If these findings are confirmed by the results of larger studies, Nordic Walking could be widely used in the early phases of cardiac rehabilitation. The influence of Nordic Walking on the cardiovascular risk factors and quality of life parameters should be investigated.

Słowa kluczowe
ostry zespół wieńcowy, rehabilitacja kardiologiczna, trening marszowy, wydolność wysiłkowa

Streszczenie
Cel: Spacery i marsze są prostą a jednocześnie efektywną formą aktywności fizycznej powszechnie stosowaną w rehabilitacji kardiologicznej. W ostatnich latach podejmuje się próby urozmaicenia ćwiczeń marszowych poprzez szersze włączenie pracy kończyn górnych, co umożliwia między innymi coraz bardziej popularna forma aktywności ruchowej znana jako Nordic Walking. Celem niniejszej pracy była ocena wpływu marszu nordyckiego na stopień poprawy tolerancji wysiłku oraz sprawność ogólną chorych rehabilitowanych po zawale serca (ZS).
Metoda: Badaniom poddano 30 pacjentów, którzy w okresie 14–28 dni po ZS przebywali na Oddziale Rehabilitacji Kardiologicznej. U wszystkich pacjentów włączonych do programu badawczego przed rehabilitacją i po jej zakończeniu wykonano próbę wysiłkową wg zmodyfikowanego protokołu Bruce'a, 6-minutowy test marszowy oraz test sprawności fizycznej „Fullerton". Chorych podzielono na dwie grupy. 10 pacjentów uczestniczyło w standardowym programie treningowym (grupa K), a u 20 pacjentów zastosowano dodatkowo (5x w tygodniu po 40 min) trening marszowy typu Nordic Walking (grupa NW). Polegał on na przejściu 3 kilometrów z przerwami przeznaczonymi na ćwiczenia oddechowe i rozciągające. W trakcie marszu oraz ćwiczeń z pacjenci wykorzystywali specjalne kije skonstruowane do tej formy aktywności ruchowej.

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Wyniki: W obu grupach trenujących uzyskano poprawę tolerancji wysiłku, jednak odsetek poprawy w grupie NW (30%) był wyższy niż w grupie K (14%). Podobnie zachowywały się wartości iloczynu podwójnego (RPP). Istotne statystycznie zwiększenie RPP po treningu rehabilitacyjnym stwierdzono jedynie w grupie z NW (z 18,2 x 10^3 ±3,3 x 10^3 do 20,7 x 10^3 ±4,4 x 10^3) ($p<0,05$). 6-minutowa próba marszowa wykazała wyższy odsetek poprawy w grupie NW (22%) niż w grupie K (17%). Wyniki testu „Fullerton" wykazują istotną statystycznie poprawę analizowanych parametrów w obu grupach.
Wnioski: Wstępne badania wskazują na celowość wdrażania marszu nordyckiego do programów rehabilitacji kardiologicznej po zawale serca z uwagi na wysoką efektywność w zakresie wpływu na poprawę tolerancji wysiłku i sprawności fizycznej. Pełne zaadoptowanie Nordic Walking jako jednej z istotnych metod wczesnej rehabilitacji kardiologicznej będzie możliwe po dokonaniu i przeanalizowaniu większej liczby obserwacji poszerzonych o dodatkowe parametry, głównie w zakresie wpływu na czynniki ryzyka oraz parametry jakości życia.

It was demonstrated that total mortality due to cardiac causes is inversely proportional to one-week caloric expenditure associated with physical effort, primarily during spare time, and – also inversely – proportional to the level of physical exercise tolerance assessed using exercise tests[1,2]. Increasing motor activity and improvement of exercise tolerance should therefore be one of the main goals of primary and secondary cardiologic prevention. Studies conducted so far, including our own observations, indicate that the level of energy expenditure during cardiac rehabilitation in a ward depend primarily on training load used during the supervised exercises, most frequently during cycloergometer training, as intensity and duration of walks are practically negligible[3]. On the other hand, marching is a natural form of motor activity, may be performed by the patients unsupervised, including after the termination of an organised form of rehabilitation[4]. Therefore, various attempts are made aiming at increasing the energy expenditure during walks while diversifying marching effort so that it is more attractive, which may favour continuation of this form of motor activity following in –patient rehabilitation. In the last years, there has been a growing interest in marching exercises, where special poles, similar to cross-country ski poles are used. This form of exercises is usually referred to as Nordic Walking and is being popularised because of a greater involvement of the shoulder girdle during the march, which considerably increases energy expenditure of this effort[5].

In the 90-ties, a possibility of using Nordic Walking during late cardiac rehabilitation (phase III) was noticed[6]. Despite encouraging results of pilot studies on the assessment of this form of motor activity in laboratory conditions during treadmill marching[7], we did not find any reports of studies evaluating the effects of introduction of this form of exercise during early rehabilitation of patients after acute coronary syndrome treated using intervention methods.

Material

The study was conducted in 30 patients aged 40–66 years (mean age: 49.0) admitted to a stationary rehabilitation centre 14–28 days (19.1 on average) after the occurrence of myocardial infarction treated with percutaneous coronary intervention (PCI).

Method

Patients enrolled in the research study were randomised into two training groups. Ten patients participated in the standard training programme (the C group), whereas in 20 patients, the Nordic Walking (the NW group), march training was additionally used, apart from the standard programme.

In all patients, exercise test on a treadmill according to the modified Bruce protocol as well as a physical agility test, the Fullerton Functional Fitness Test, were performed before and after termination of rehabilitation. The Fullerton Functional Fitness Test was designed in Lifespan Wellness Clinic at California State University in Fullerton by R.E. Rikli and C.J. Jones. Its usefulness was documented in the assessment of some physiological parameters necessary in every-day activity, such as: exercise tolerance, physical strength endurance, flexibility and coordination[8,9,10].

The standard training programme involved participation in training sessions conducted five times a week, comprising general agility exercises and cycloergometer training (load levels adjusted according to the heart rate). The intensity and duration of the exercises were based on the recommendations of the Section of Rehabilitation and Exercise Physiology of the PTK (Polish Society of Cardiology)[8]. Nordic Walking exercises were also conducted five times a week.

Specially designed poles were used in the marching training. Their length was adjusted to patient's height.

Patients walked a distance of 3 km on hardened paths located close to the hospital, on wooded, flat grounds. Intensity of the marching effort was supervised using pulse monitoring with the polar-system (training pulse, comparable to that constituting the basis of the regulation by load during cycloergometer exercise, was used). The marching training was always performed after general agility exercises used for warming-up. Teaching the patients to walk using the Nordic Walking technique was started with the traditional form of walking, while upper limbs activity was gradually introduced as well as the poles were added so that the walk resembled the movement of a cross-country skier. At half-way (after approx. 1500 m), the march was interrupted and respiratory exercises combined with stretching exercises were performed. Prior to commencing the study, the participants took part in a specialised Nordic Walking course organised by INWA (International Nordic Walking Association). During the rehabilitational training, methods recommended by INWA were used[11]; however, regarding the intensity, duration and type of the selected exercises, the methods were adjusted to patients' abilities determined by their cardiovascu-

lar and motor system status, based on our own experience and the standards of early management of post-myocardial infarction patients.

The adjustment involved such a selection of march and exercise intensity so that the training pulse rate determined in the exercise test would not be exceeded (on the 1, 2, 3 days of the training – 40–50% of heart rate reserve, and 50–60% of heart rate reserve on subsequent days). The total training duration did not exceed one hour. Several originally recommended exercises with a large isometric abandont, and the number of repetitions of dynamic exercises was reduced to 10 and subsequently to 15. After the marching training was finished, patients rested for approx. 30 minutes and subsequently, the cycloergometric exercise was conducted. The patients had 15 training sessions altogether.

The Mann-Whitney U test and the Wilcoxon signed rank test were used in the statistical analysis.

Appropriate Bioethical Committee approved the conduction of this study.

Results

Results of the treadmill exercise test are presented in the Figure 1. Both groups did not differ significantly with regard to baseline and post-training exercise tolerance; there was also a significant improvement after the rehabilitation cycle within both groups of patients ($p<0.05$). However, the percentage of the improvement in the NW group (30%) was significantly higher than in the C group (14%). Similarly, the rate-pressure product (RPP) did not differ between the two groups either in the baseline or post-training testing, whereas a statistically significant increase in RPP after the rehabilitation training (from 18.2 x 10^3 ± 3.3 x 10^3 to 20.7 x 10^3 ± 4.4 x 10^3) was observed only in the NW group ($p<0.05$) (Figure 2).

The next figures present results of particular components of the Fullerton test. It should be noted that the variant of the test with 6-minute marching trial in a form of the corridor test was selected. Results of the marching trial were analogical to

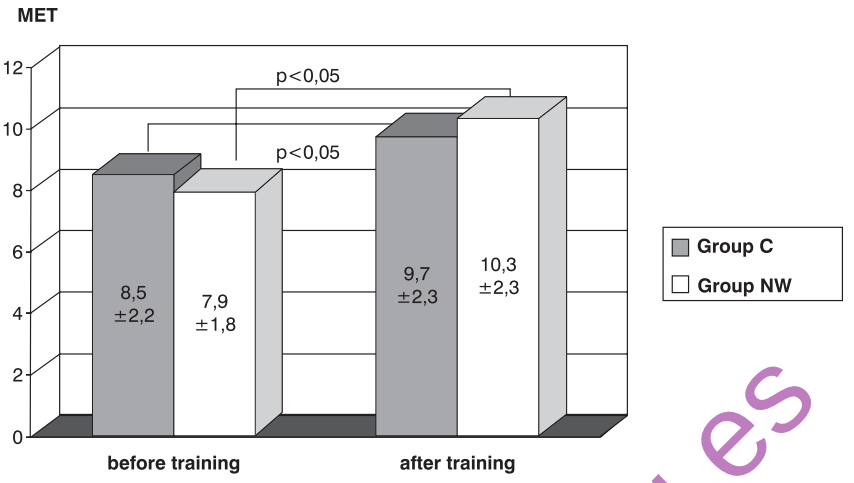

Figure 1
Treadmill exercise test

Figure 2
Peak rate-pressure product during treadmill exercise test

those of the treadmill test. No differences were found between the groups, while there was a statistically significant improvement after the training ($p<0.05$). Also in this test, a higher percentage of improvement was found in the NW group (22%) as compared to the C group (17%) (Figure 3).

The remaining components of the test were:

1. Upper body strength endurance test – the patient in the sitting position – flexing the dominant forearm with a 3 kg weight. Number of repetitions within 30 seconds is assessed.
2. Lower body strength endurance test – rising from and sitting down on a chair. Number of repetitions within 30 seconds is assessed.
3. Upper body flexibility assessment – putting the arms on the back, hands to be clasped behind – the dominant hand from above, the non-dominant from below. The distance between the middle fingers of outstretched hands is measured.
4. Lower body flexibility – the patient in the sitting position, on a chair, one leg outstretched, the other flexed. A bend forwards is performed and the distance between the toes of the foot flexed at 90ş angle and the fingers is measured.
5. Coordination test – rising up from a chair, walking a distance of 1.22 m twice and terminating with sitting down on the chair. The time of performance of this task is measured.

Results of the above test's components are presented in figures 4–8.

An improvement in the majority of the analysed parameters was dem-

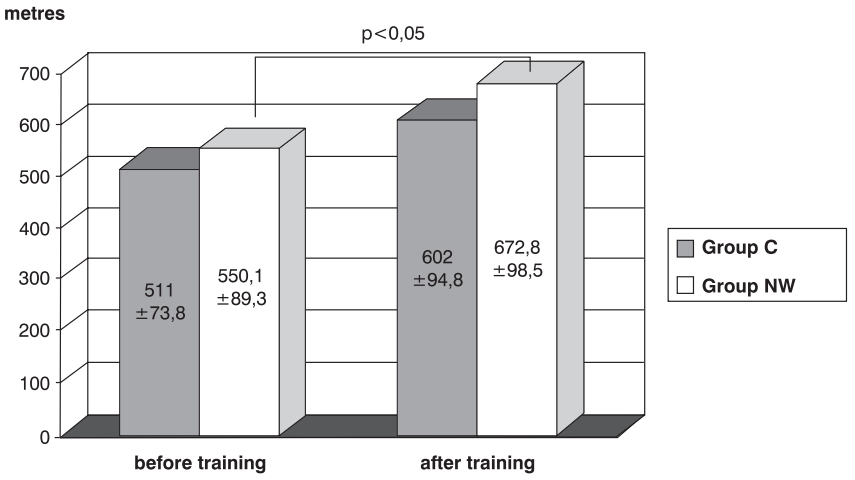

Figure 3
Six-minute walk test

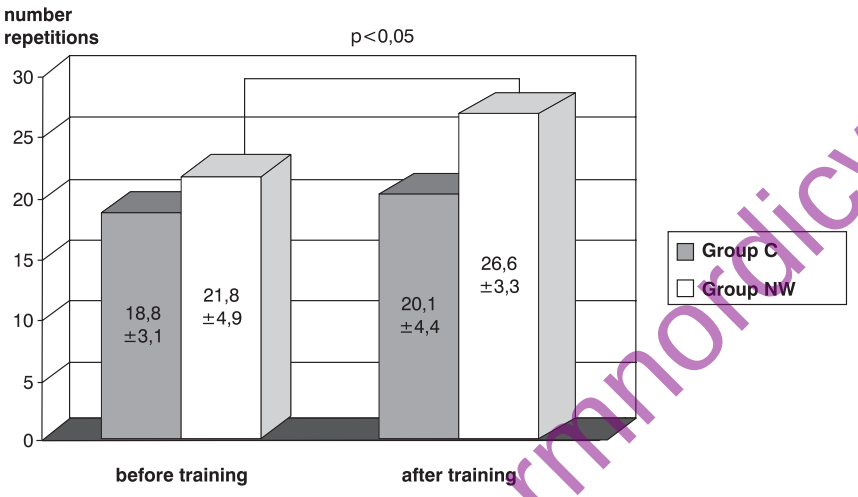

Figure 4
Strength endurance – upper part of the body

Figure 5
Strength endurance – lower part of the body

onstrated in both patient groups. In the strength endurance tests (forearm flexion with a weight and rising from a chair tests), the number of flexions within 30 seconds increased in the NW group from 21.8 ±4.9 to 26.6 ±3.3 and in the C group from 18.8 ±3.1 to 20.1 ±4.4; the number of repeated tasks – standing up/sitting down – increased from 15.5 ±3.4 to 18.1 ±3.9 in the NW group and from 13.5 ±3.1 to 16.7 ±5.7 in the C group ($p<0.05$). In the coordination test, time of the 5 m walk was shortened from 4.6 ±0.5 sec. to 3.9 ±0.4 sec. in the NW group ($p<0.05$), but only insignificantly (5.1 ±1.0 sec. to 5.0 ±0.9 sec.) in the C group. In the flexibility tests, the average distance between the hands during the attempt of their clasping on the back decreased from –9.2 ±14.8 cm to –2.9 ±14.1 cm in the NW group, and from –13.5 ±12.5 cm to –5.4 ±7.6 in the C group, while the distance between the hand and the toes during bending forward changed from –2.6 ±8.9 cm to 6.2 ±8.1 cm in the NW group and from –4.8 ±7.9 cm to 4.3 ±12.4 cm in the C group ($p<0.01$).

During the exercises, no cardiovascular undesirable effects occurred in any of the groups that would require a reduction in training intensity or its termination. The training was stopped only in one patient, who complained of strong pain in the shoulder girdle during marching with the poles. The patient had had stabilising surgery of the cervical spine because of advanced degenerative changes in the past.

Discussion

Marching with the poles similar to those used in cross-country skiing is an increasingly common form of physical training in persons of various age and fitness. Nordic Walking has significantly expanded beyond the Scandinavian borders, the territory of its origin, within the last 10 years and begins to be more and more seen in parks, on meadows and in forests of the whole Europe and North America. In the studies conducted hitherto, it was shown that owing to Nordic Walking, energy expenditure may be augmented by over 20% in comparison to the traditional march at the same speed[5,6,7,11,12]. Beneficial effects in improvement of exercise tolerance were also demonstrated in both men and women of different age and lifestyles. Psychological advantages of this form

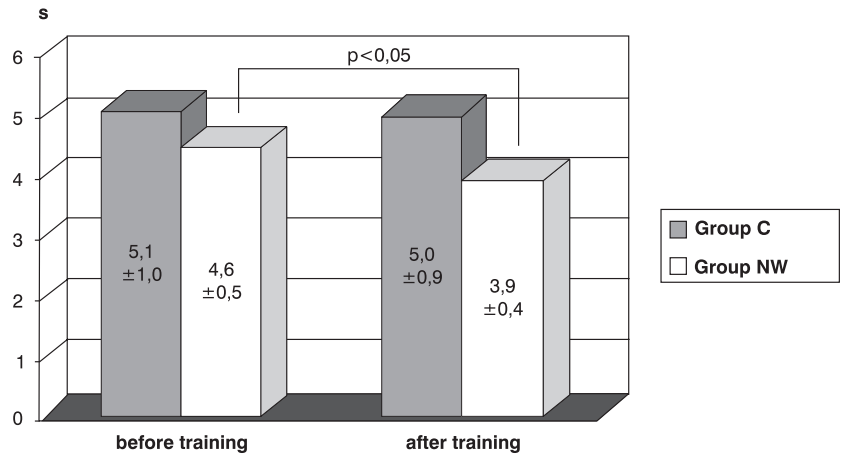

Figure 6
Coordination test

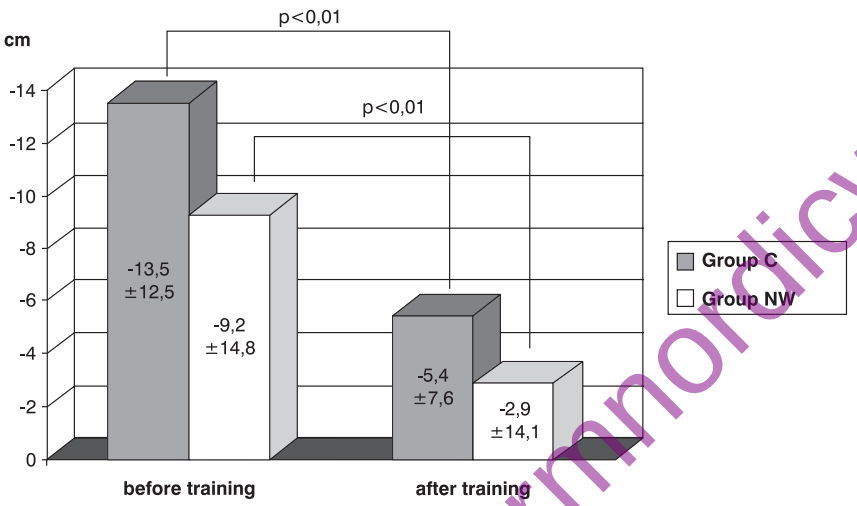

Figure 7
Flexibility – upper part of the body

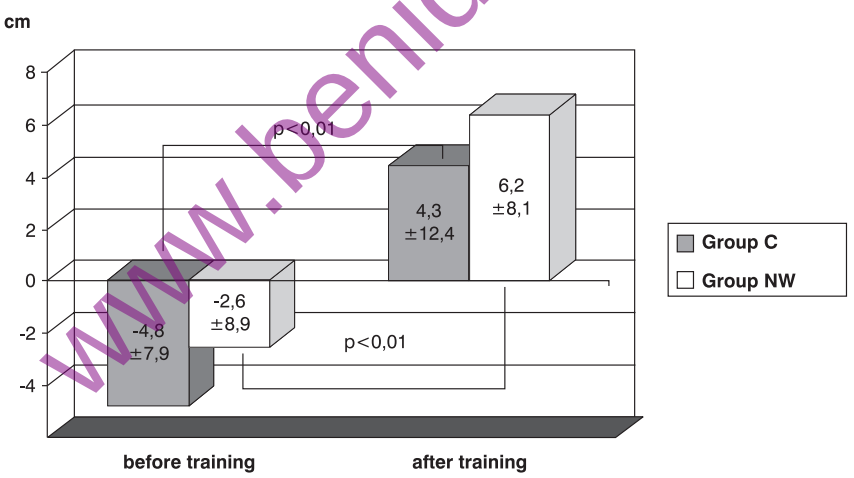

Figure 8
Flexibility – lower part of the body

of activity were also emphasised[12]. Trials of using Nordic Walking in rehabilitation exercises have been scarce so far and were performed in patients with lower extremities atherosclerosis and Parkinson's disease[12,13,14,15,16]. As already mentioned, there have been no published results of any observations on the efficacy of introducing Nordic Walking to cardiac rehabilitation programmes despite the fact that studies by Walter et al.[6] demonstrated that such effort is well tolerated by the patients with coronary artery disease, including patients with coronary artery bypass grafts. Our study is likely the first attempt of verifying the efficacy of the Nordic march as a form of endurance training in patients rehabilitated at early phase after acute coronary syndrome treated with PCI.

Observations made in this study are a part of a wider therapeutic programme encompassing also analysis of cardiovascular responses to march-associated effort and verification of energy expenditure and metabolic effects of the training in patients subjected to early cardiac rehabilitation. From the results of pilot studies presented here, it is clear that this form of exercise is encouraging. Introduction of Nordic Walking into the rehabilitation programme has lead to the achievement of better exercise endurance as compared to the effects of the standard programme. This was demonstrated both in the treadmill test and the 6-minute march trial. Beneficial effect of the training on effort tolerance in the NW group is probably associated with increased energy expenditure in comparison to the group not performing the supervised marching efforts. This, however, requires detailed verification in further studies. In our opinion, the improvement may not only be associated with the introduction of a supervised form of marching, augmenting energy expenditure, but also with a specific influence of the Nordic march. Results of the analysis of other elements affecting physical fitness in a range necessary for the patients to perform activities of daily living, are also indicative of such influence. For this purpose, a test designed by Jones and Rikli, more and more frequently named – after the site of its origin – the Fullerton test, was used, probably for the first time in early rehabilitation, [9,10]. The test, originally designed for the elderly, seems to be also useful for the verification of training outcomes in early cardiac rehabilita-

tion. This form of evaluation still requires detailed validation of its usefulness in larger studies; however, already at this point, thanks to the use of this method in our patients' assessments, we obtained next important evidence indicating outstanding effects of the rehabilitation exercises in improving physical fitness. This refers both to the rehabilitees exercised using standard methods and – in particular – to the patients trained according to the programme expanded with Nordic Walking.

The march – a rhythmic, dynamic form of motor activity, conducted in aerobic conditions with involvement of large muscle groups, should still be considered as the basic form of motor activity in the rehabilitation and secondary prevention.

Morris and Hardman[4], authors of an interesting monograph on health aspects of marching efforts end their work with a quotation from a literary text by Trevelyan, as of 1913: "I have two doctors, my left and my right leg". We are convinced that, already at present, post-heart infarction rehabilitees, for the sake of better effects of rehabilitation, should be offered not two, but six doctors, i.e. two legs, two arms and two poles[4].

Conclusions

Preliminary studies indicate that introducing Nordic Walking into cardiac rehabilitation programmes is advantageous because of its high efficacy in improving exercise tolerance and physical fitness. Complete adaptation of Nordic Walking as one of important methods of early cardiac rehabilitation will be possible after the performance and analysis of a greater number of observations expanded with additional parameters, mainly those affecting risk factors and indices of quality of life.

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References

1. Blair S.N., Kohl third H.W., Paffenbarger Jr R.S., Clark D.G., Cooper K.H., Gibbons L.W.: Physical fitness and all-cause mortality. A prospective study of healthy men and women. JAMA 1989; 262: 2395–401
2. Laukkanen J.A., Kurl S., Salonen R., Rauramaa R., Salonen J.T.: The predictive value of cardiorespiratory fitness for cardiovascular events in men with various risk profiles: a prospective population-based cohort study. Eur Heart J 2004; 25: 1428–37
3. Wilk M.: Ocena wpływu różnych form treningu wytrzymałościowego na tolerancję wysiłku u chorych rehabilitowanych po zawale serca. Praca doktorska. AWF Poznań 2001
4. Morris J.N., Hardman A.E.: Walking to Health. Sports Med. 1999; 23: 306–32
5. Church T.S., Earnest C.P., Morss G.M.: Field Testing of Physiological Responses Associated With Nordic Walking. Resarch Quartetly for Exercise and Sport 2002; 73: 296–300
6. Walter P.R., Porcari J.P., Brice G., Terry L.: Acute Responses to Using Walking Poles in Patients With Coronary Artery Disease. J Cardiopulmonary Rehabil 1996; 16: 245–50
7. Porcari J.P., Hendrickson T.L., Walter P.R., Terry L., Walsko G.: The Physiological Responses to Walking With and Without Power Polars on Treadmill Exercise. Resarch Quartetly for Exercise and Sport 1997; 68: 161–6
8. Kompleksowa Rehabilitacja Kardiologiczna. Stanowisko Komisji ds. Opracowania Standardów Rehabilitacji Kardiologicznej Polskiego Towarzystwa Kardiologicznego. Folia Cardiologica 2004; 11(supl.A): A1-A48
9. Rikli R.E., Jones C.J.: The development and validation of a functional fitnes test for community-residing older adulte. Journal of Aging and Physical Activity 1999; 7: 129–61
10. Jones C.J., Rikli R.E.: Assessing Physical Performance of Older Adults in a Community Setting. Perspectives 2000; 2: 28–47
11. Arvonen S.: Sauvakavelyohjaajan opas. Nordic Walking instructor Manual. Suomen Latu. Helsinki 2003
12. Rodgers C.D., Vanheeest J.L., Schachter C.L.: Energy expenditure during submaximal walking with Exerstriders. Med Sci Sports Exerc 1995; 607–11
13. Laukkanen R.: Review: Scientifice evidence on Nordic Walking. INWA 2004, Decemb. 8
14. Collins E., Langbein W.E., Orebaugh C.: Polestriding exercise and vitamin E for management of peripheral vascular disease. Med Sci Sports Exerc 2002; 3: 389–93
15. Langbein W.E., Collins E.G., Orebauch C., Maloney C., Williams K.J., Littooy F.N., Edwards L.C.: Increasing exercise tolerance of persons limited by claudication pain using polestriding. J Vasc Surg 2002; 35: 887–92
16. Baatile J., Langbein W., Weaver F., Maloney C., Jost M.: Effect of exercise on percived quality of life of individuals with Parkinson's disease. J of Rehabilitation Research and Development 2000; 37(5): 9–10

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