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Review: Scientific Evidence on Nordic Walking

This paper reviews 52 scientific articles published on Nordic Walking in years 1992-2006. Papers or results with at least English abstract are included. Studies are classified according to the target group into four categories:

1. Nordic Walking studies related to health and healthrelated fitness (done on sedentary, on elderly individuals or in patients)
2. Nordic Walking studies related to fitness (done on physically active individuals)
3. Nordic Walking studies related to sports type of performance (done on athletes)
4. Other (done on various groups, reviews, fitness assessment, safety and popularity of NW)

References of all studies are listed in alphapethical order.

1. Studies related to health

First research results on responses to pole walking training were published in 1992 by Stoughton, Larkin and Karavan from the University of Oregon. They studied psychological profiles (mood states) as well as muscular and aerobic fitness responses before and after 12 weeks of exerstriding or walking training in sedentary women. Exertriding is a modified form of walking that incorporates the use of specially designed walking sticks (Exertriders®) in a standard walking workout. This study group consisted of 86 2050 year old women whose fitness was at moderate level. Maximal aerobic power (VO_{2max}) varied between 3437 ml/kg/min. A study group was divided into three subgroups. Control group retained all their exercise habits. Walking and Exertrider groups walked 3045 minutes four times a week at an intensity corresponding to 7085 % maximum heart rate for twelve weeks. In Exertrider group both the walking speed and the distance walked were slightly less than in the walking group.

In both groups the maximal aerobic power and maximal treadmill time increased significantly. These increases were 8 and 19 % on an average. A slight increase in maximal ventilation occurred in the Exertrider group, but not in the walking group. Muscular endurance improved in the Exertrider group by 37 % and in the walking group 14 %. Muscular strength assessed using triceps pushdown and a modified lateral pulldown did not improve in either group. Exerstider walkers showed significant improvements in depression, anger, vigor, fatigue, total mood disturbances and total bodycathexis scores. The walking group showed significant improvements only in vigor and total bodycathexis. It was speculated that the Exertrider group may have felt more unique and special because of their opportunity to participate in a new and more enjoyable method of walking.

Exerstriders were also compared to weighted vests, ankle weights, hand and wrist weights, weighted gloves and Powerbelts™ by Porcari (1999) with similar results as above.

The effort involved during Nordic Walking has also been investigated in coronary heart patients (Walter et al. 1996). In this study fourteen men aged 61 years walked two eight minute repetitions: the first consisted of normal walking, while during the second the subjects used half kilogram poles. The subjects walked at the maximum pace allowed in light of their symptoms. All subjects had had either heart bypass or angioplasty operations or had suffered cardiac infarctions. During pole walking average energy consumption increased 21%, heart rate by 14 beats/minute and highest systolic/diastolic blood pressure figures by 16 and 4 mmHg respectively when compared with figures obtained during normal walking. Oxygen pulse figures (i.e. oxygen consumption multiplied by heart rate) are indicative of changes in oxygen consumption and are not connected with undesirable rises in blood pressure. The research group concluded that pole walking is a safe form of rehabilitation for heart patients.

A Finnish study (Anttila et al. 1999) compared Exel polewalking with regular walking training for 12weeks on 55 female office workers. EMGmeasurement showed that electrical activity of the muscles in the upper body (neckshoulderupper back) was significantly higher when walking with poles. Polewalking training diminished neck and shoulder symptoms and subjective feeling of pain. Mobility of the upper body increased as well. Similar results were obtained also in the study by Karvonen et al. (2000). They did study neckshoulder area pain on 31 4450 year old persons who had no previous experience on Nordic Walking. Exercise group trained twice a week for ten weeks for 60 min per session. Nordic walking decreased neck and shoulder pain in general and at work. In addition, disturbance of neck and shoulder stiffness and pain in the movement of head were significantly decreased. A third study (Koskinen et al. 2003) examined the effectiveness of NW on ageing employees on their postural control as well as on the muscular strenght of lower extremities and the middle trunk. Subjects (n=24) were 45 to 61 year old, majority of them women. They did NW three times weekly and partly instructed. The group improved in healthrelated fitness parameters evaluated by the Fitness Test battery developed by UKK Institute.

In a study by Baatile et al. (2000) 16 72year old veteran males with Parkinson´s disease did Nordic Walk for 8weeks in an interval training program three times weekly for 60 min per session with perceived rating of intensity (Borg 13). Researchers concluded that regular NW exercise program increased perceived functional independence and quality of life in individuals with Parkinson Disease.

The aim in Parkatti et al. study (2002) was to examine the benefits of NW on functions important to everyday life among older sedentary individuals in Virginia, USA. Altogether 18 73year old (6287 yrs) person participated. They exercised 60 min twice a week for 12 weeks (10 min warmup, stretcting in the middle and cooldown at the end) by Nordic Walking. Functional capacity battery of tests including chair stand, arm curl, chair sit and reach, scratch test, 2 min step in place and ”up and go” test was used before/after intervention. A health questionnaire was also used. The results of all functional tests were statistically signifigantly better after training. The study showed that NW is suitable for elderly and effective to affect functional capacity.
In 2003 Collins et al. published a study where they studied 52 (6570 yrs) patients with peripheral vascular diseases (PVD). The program consisted of three weekly sessions of pole walking for 3045 min . Vitamin E (dose 400 IU daily) was also studied. Pre and post intervention peak oxygen uptake, Quality of Life interview and biweekly ankle blood

pressure measurements were conducted. Pole group improved exercise tolerance significantly, they had also less claudication pain after exercise. Additionally, distance and walking speed improvement in pole groups. Researchers concluded that pole walking effectively improved both exercise tolerance and perceived quality of life of patients with PVD. Evitamin caused little additional benefit. The same goup also published another paper (Collins et al. 2004), in which the 24week training data of 49 patients with peripheral arterial disease were studied. Persons with PAD were randomized into a 24week PS training program or a nonexercise attention control (C) group. PS exercise entails walking with modified ski poles using a movement pattern similar to crosscountry skiing. Those assigned to the PS group trained three times weekly. Control group subjects came to the laboratory biweekly for ankle blood pressure measurements.Asymptomlimited ramp treadmill test, ratings of perceived leg pain, and QOL data were obtained at baseline and upon completion of the training program. After 24weeks of PS training, subjects increased their exercise endurance from 10.3 +/ 4.1 min to 15.1 +/ 4.5 min. This was significantly greater 7.46, p<0.001) than C group subjects whose exercise endurance declined (11.2 +/ 4.7 to 10.3 +/ 4.7 min). Systolic blood pressure ($p < 0.001$), heart rate ($p = 0.04$), rate pressure product $p = 0.05$), oxygen uptake ($p = 0.016$) and perceived leg pain over exercise time at the baseline and sixmonth symptomlimited treadmill test were greater in the PS group when compared to the C group. The change in the physical component summary score of the SF36 was also greater in the PS group when compared to the C group ($p = 0.03$). Conclusion was that the training significantly improved the clinical indicators,increased cardiovascular fitness, improved the perception of the physical component of healthrelated QOL, and decreased symptoms of claudication pain during exertion in these patients.

The purpose of a research by KukkonenHarjula et al. (2004,2007) was to study training responses of brisk walking with or without poles on cardiorespiratory fitness (both in submaximal and maximal exercise) and on some other indicators of healthrelated fitness in healthy middleaged women. Training prescription was aimed at moderate intensity (5085 % of HR reserve, HRR). Twohundredandtwelve women volunteered. Their age was 5060 years, no major health problems, BMI 2030 kg x m^2 and leisure exercise training no more often than twice weekly. After screening examinations 121 women were accepted and randomized into a NW or a walking (W) group. Walking and NW techniques were instructed in small groups. Training intensity was selfquided and turned out to be the same in both groups (Mukka 2004). Training was 4x weekly for 40 mins, intensity 53% HRR, Borg 13.7. The increase in peak VO_2 (about 8 % in both groups) during 13 week training was modest. The study also showed that the mode of maximal exercise testing (with or without poles) had no influence on peak VO_2 and its change during training in women with initially little familiarity with NW technique.

In a study by Aigner et al. (2004) 20 untrained healthy individuals (average age 47 years) were studied while walking with or without poles on separate days. The speed of walks was 7.9 km/h on an average and mean heart rate 165 and 158 bpm with and without poles. The corresponding blood lactate levels were 5.7 and 5.0 mmol/l. In all speeds between 3 to 7 km/h heart rates and lactates were significantly higher in Nordic Walking conpared to regular walking.

Heikkilä et al (unpublished 2004) studied NW in 13 3354year old overweight (BMI 32 kg/m^2) individuals. Subjects exercised by NW regularly for 4 months with HR controlled and with progressive load. The results showed that subjects lost weight (5kg on an average) and body fat (waist –6.6 cm), improved in aerobic fitness (+29%), and in blood lipids. According to the researchers, the key factors to these very positive results were the moderatehigh intensity of training andits progressive nature.

Wilk et al. (2005) studied NW in 16 acute coronary disease patients in Poland.
Based on this exercise intervention they concluded that NW is a meaningful activity for cardiac rehabilitation.
Nordic walking has also been studied in cancer patients. The purpose of a recent study by Sprod et al. (2005) was to determinate the effects of walking pole use on shoulder function in female breast cancer survivors. Twelve 5059 year old participants were randomly assigned into experimental or control groups for 8 weeks. Exercise program consisted of two 20 min aerobic training sessions at the intensity of 4050% HRR. Additionally both groups performed 30 min of resistance training after aerobic session. No within group improvements were found in the control group. The experimental group improved muscular endurance of the upper body. This was concluded to be beneficial in helping them perform activities of daily living and regain an independent lifestyle.

In a study by Schöttler et al. (2005) Nordic Walking was studied for prevention in 150 patients with various orthopedic problems. They exercised 3090 min three times weekly with a trained instructor and many of them also at home by themselves. The results and experiences were surveyd by a questionnaire. 93% felt that their endurance capacity increased and in 55% body weight was reduced. Additionally, resistance to stress improved in 63% of patients and 21% felt that NW training improved their sleep.

Nordic Walking was researched in type 2diabetes patients by Nischwitz et al. (2006). Altogether 6 women and 13 males with the mean age of 67 years participated in NW 1 to 2 times weekly for 90 minutes for 1 year. Blood glucose values were taken at start and at 45 and 90 min during and 2 hours after walking sessions. Life quality qestionnaires were completed at 3 month intervals. The overall results were very engouraging indicating improvements in all diabetesrelated metabolic parameters and a reduction in the use of diabetes medication.

2. Studies related to fitness

The physiological responses to walking with and without Power Poles™ were studied by Hendrickson (1993) and by Porcari et al. (1997). Power Poles are specially constructed, rubbertipped ski poles designed for use during walking. Hendrickson´s study group consisted of sixteen fit women (VO_{2max} 50 ml/kg/min) and men (59). They walked with and without poles on a treadmill with the speeds of 67,5 km/h. There were no differences in the responses between males and females. It was found that the use of poles significantly increased oxygen uptake, heart rate and energy expenditure by approximately 20 percent compared to the walking without poles in fit subjects. In Porcari's study on 32 healthy men and women walking with poles resulted in an average of 23% higher oxygen uptake, 22% higher caloric expenditure and 16% higher heart rate responses compared to walking without poles on a treadmill. RPE values averaged 1,5 units higher with the use of poles and the pattern of responses was similar for men and women.

A dualmotion treadmill Cross Walk has been studied by Knox (1993), Foley (1994) and by Butts et al. (1995) . The Cross Walk Dual Motion Cross Trainer is a motorized treadmill designed to increase the energy cost of walking by incorporating arm activity during walking, thus increasing the muscle mass used during exercise. The activity is not the same as field walking with poles, but can be used as reference to NW. Knox studied thirtyseven 1735 year old women.They all performed six 5min steadystate exercises with and without arm activity. Walking with arm activity increased significantly heart rate, ventilation, oxygen uptake and energy expenditure compared to walking without arm activity. E.g. heart rate increased 1731 beats per minute. Rating of perceived exertion as well as energy expenditure increased with an average of 14 percent. In Butt's study both the 24year old women and men were studied with a similar design. In this study arm work increased energy expenditure by 55 % on an average compared to regular walking, but increased rating of perceived exertion only little. This was consistent with the results from Foley, who studied Cross Walk in 24yearold men.

Rogers at al. (1995) compared energy expenditure during submaximal walking with Exerstriders® in ten 24 year old fit women. Mean maximal aerobic power (21 vs. 18 ml/kg/min) and heart rate (133 vs. 122 bpm) were significantly greater during the walking with poles compared to walking without. Also the total caloric expenditure in a 30 minute session was significantly greater during pole walking (174 vs. 141 kcal). In contrast, the rating of perceived exertion did not differ significantly between the two conditions.

Laukkanen (1998, unpublished)compared heart rate during normal and fast walking speeds with and without Exel Walker poles. Ten middleaged men and women were studied on an indoor hall track. The heart rate increase, measured with telemetric Polar HR monitor, was between 512 bpm and 517 bpm in women and men.

The purpose of the study by Knight and Caldwell (2000) was to compare pole and nopole conditions during uphill backpacking, which was simulated on an inclined treadmill with a moderately heavy (22.4 kg, 30% body mass) backpack. Physiological measurements of oxygen consumption, heart rate, and RPE were taken during 1 h of backpacking in each condition, along with joint kinematic and electromyographic comparisons from data collected during a third test session. The results showed that although imposing no metabolic consequence, pole use elicited a longer stride length (1.27 vs 1.19 m), kinematics that were more similar to those of unloaded walking, and reduced activity in several lower extremity muscles. Although pole use evoked a greater heart rate (113.5 vs 107 bpm), subjects were backpacking more comfortably as indicated by their ratings of perceived exertion (10.8 vs 11.6). The increased cardiovascular demand was likely to support the greater muscular activity in the upper extremity, as was observed in triceps brachii. By redistributing some of the backpack effort, pole use alleviated some stress from the lower extremities and allowed a partial reversal of typical loadbearing strategies.

In a study by Jacobson et al (2000) load carriage energy expenditure with and without the use of hiking poles was studied. Twenty male volunteers aged 2048yr completed two random treadmill trials with poles (E) and without poles (C). Poles and load (15 kg backpack) were fitted for each subject according to the manufacturers' recommendations. Heart rates (HR), minute ventilation (V(E)), oxygen consumption (O2), caloric expenditure (Kcal), and rating of perceived exertion (RPE) were recorded at the end of each minute. Two trials separated by one week consisted of treadmill walks at a constant speed of 1.5 mph for1 min at 10% grade, 2 min at 15% grade, 2 min at 20% grade, and 10 min at 25% grade. Analysis of paired time points yielded no significant differences in HR, VO2, V(E), and Kcal, however, RPE means were significantly lower for 5 of the last 7 trial minutes with the use of poles. These results suggest that during load carriage on moderate grade, the weight and use of hiking poles does not increase energy expenditure but may provide reduced perceptions of physical exertion.

Gullstrand & Svedenhag (2001) from Sweden studied acute physiological effects on walking on a treadmill with or without poles. This study on 13 55year old subjects showed that VO_{2max}, VE, blood lactate and HR did increase, but RPE (rating of perceived exertion) remained unchanged in NW compared to regular walking

In the study published by the Cooper Institute group from Texas, USA the metabolic cost of NW was compared to normal walking in 22 31yearold men and women (Morss et al. 2001, Church et al. 2002). Participants of this study walked on an outdoor 200m track with Cosmed K4b for oxygen consumption and Polar Vantage heart rate monitor for HR measurements. Study indicated significant increases of oxygen consumption (20% on average), caloric expenditure and HR in NW compared to normal walking. The range of increase was large, i.e. in oxygen consumption 563% indicating differences in poling intensity and technique. Perceived exertion did not differ between the walks. Thesame group also compared separately metabolic cost of high intensity poling (Jordan et al. 2001). In high intensity poling NW increased HR 35 bpm on an average compared to regular walking.

In a study by Willson et al. (2001) the purpose was to determine whether walking with poles reduces loading to the lower extremity during level over ground walking. Threedimensional gait analysis was conducted on 13 healthy adults who completed 10 walking trials using three different poling conditions (selected poles, poles back, and poles front) and without the use of poles (no poles). Results showed that there were differences in kinetic variables between walking with and without poles. The use of walking poles enabled subjects to walk at a faster speed with reduced vertical ground reaction forces, vertical knee joint reaction forces, and reduction in the knee extensor angular impulse and support moment, depending on the poling condition used.

Bohne study (2002) studied pole use effectiveness during downhill hiking in 20 men and women. Gender differencies were found indicating that men decreased ground reaction forces with poles at steeper hill (25º) than women (20º did.

A study done in Germany by Ripatti (2002) 24 individuals (48±8 yrs) did NW for 6 weeks 2 times weekly for 60 min (6585 %HRmax). This improved their endurance capasity even when walking at a lower speed.

Parker et al. (2002) compared metabolic responses to graded exercise walking with and without poles in 14 physically active 30year old subjects. The comparisons of heart rate and metabolic parameters were done in laboratory on treadmill and using crosscountry skiing poles. The tests did not show any difference between the exercise modes.

Effects of regular Nordic Walking training in elderly (mean age 76 years) men and women was studied by Luomaaho (2002). Subjects walked 3 times 50 minutes weekly for two months. The performance in a sixminute test improved 14%, maximal walking speed 20%, and balance 4%. Selfrated health improved 22%, selfrated physical fitness 24% and performance in the physical activities of daily living 30%.

Mänttäri et al (2004) conducted a pilot study for KukkonenHarjula et al. intervention study (2004). In this pilot they compared the cardiorespiratory and musculoskeletal responses of NW and W in field conditions in middleaged women, with three selfguided exercise intensities. After screening examinations 20 middleaged women performed a maximal exercise test on a treadmill with poles. All the subjects were familiar with Nordic walking or crosscountry skiing. These results showed that Nordic walking increased the mean HR compared to regular walking only from 2.6% to 4.9% and the mean VO_2 from 2.5% to 10.8%, during the three different selfguided walking intensities. This increase seems to be due to the increased muscle activity in the upper body muscle groups. Compared to previous studies the statistically significant mean differences between NW and W were modest.

In Kleindienst et al. study (2006) the biomechanical differences between the locomotion patterns of NW, walking and running were studied in eleven subjects experienced in NW. High speed camera systems picturing simultaneous posterior and lateral movements were used. The data reveal differences between the three analysed locomotion patterns. For NW as well as walking the mechanical load of the lower extremity was lower compared to running. None of the kinematic parameters suggested a "physiological benefit" of NW compared to walking. Moreover NW shows higher vertical and horizontal forces during landing. Exclusively the lower vertical force peak during push off indicated a lower mechanical load for NW in comparison to walking. The authors concluded that it is questionable if NW based on its promised "biomechanical benefits" compared to walking should be recommended for overweight people and for people with existing musculoskeletal problems of the lower limb.

In a study by Valkonen (2005) the purpose was to examine the effect of the intensity of arm work on VO_2, EE and muscle electromyographic activity in Nordic walking. Nine healthy subjects (5 females and 4 males, 2227 years) all performed three 30 min exercise tests (walking, W, normal Nordic walking, NNW and easy Nordic walking, ENW) on a motorised treadmill with 6 km/h speed and 1° inclination. The results demonstrated that the VO_2 was significantly higher (9.1 %) in NNW than in W and 5.5 % higher than in ENW. The EE was also significantly higher (10.0 %) in NNW than in W and slightly higher (4.6 %) than in ENW. The differences in VO_2 and EE between ENW and W were not statistically significant. Combined surface EMGactivity of all the muscles measured in this study (m. erector spinae, m. deltoideus, m. gastrognemius, m. triceps brachii and m. vastus medialis) was significantly higher both in NNW and in ENW than in W. The difference between NNW and ENW in EMG (7.4%) did not reach the level of statistical significance. No correlations between the combined EMGactivity of the muscles measured in this study and VO_2 or EE could be observed although EMG, VO2 and EE all followed the same pattern (lowest in W and highest in NNW). The results of this study emphasize the importance of effective usage of arms in Nordic walking in elevating the VO_2 and EE above the level observed in walking without walking poles.

In a study by Schiffer (2006) the physiological responses during incremental field tests (FT) in Nordic walking (NW), walking (W) and jogging (J) were studied. Fifteen healthy middleaged women participated in three FT. Heart rate (HR) and oxygen uptake were monitored continuously by portable analysers. As a main result and conclusion the authors stated that as NW speed at submaximal lactate levels is lower than in W and J, W and J test measures of HR are not suitable for NW training recommendations.

3. Studies related to sports

In a Norwegian study by Haugan and Sollesnes (2003) 16 sports students (22 yrs) were measured in a laboratory walking at the speeds of 5.5, 6.0 and 6.5 km/h with or without poles on an elevated treadmill (17%). Half of the subjects were crosscountry skiers. Oxygen uptake increased significantly at all speeds when using poles in walking in others, but not in cc skiers.

4. Other

Nordic Walking has also been under study in The Netherlands. Lande et al. published in 2003 a systematic review of the physiological effects of pole walking.

Parkkari et al. (2004) evaluated injury risk in various commuting and lifestyle activities in a cohort of 3657 1574year old Finns. The individual injury risk per exposure time was overall relatively low, ranging from 0.19 to 1.5 per 1000 hours of participation. Highest risk in all recreational and competitive sports was in squash (18.3) , judo (16.3) and orienteering (13.6). In Nordic Walking (pole walking) the risk was 1.7. In the cohort 11 % participated actively in this sport.

Knobloch and Vogt (2006) studied safety of NW training prospectively by questionnaires in 137 persons with the mean age of 53 years. Injury rate was 0.93/1000 hours of training. The most frequent injury was distorsion of the ulnar ligament of the thumb, following with the shoulder and gastrocnemius muscle injuries. Recovering back to normal training took place in 4 weeks. Overall conclusion of this large scale study was that NW is safe.

UKK Walk Test is a popular test for aerobic fitness assessments in large population surveys since it is easy, safe and cost effective. The Test has been developed for and aimed to be done with regular walking style. Widmann et al. (2005) studied the possible differencies in conducting the 2km UKK test with regular walking style or with nordic walking. Altogether 17 women (mean age 55 years) participated in the Test with and without poles on two different days. The results did not show any differencies in walking time and in physiological parameters (heart rate, respiratory quotient, oxygen uptake, blood lactate, energy expenditure). The result was the same in those who had good technique compared to the less skilled individuals.

In a questionnaire study by Schmidt et al. (2004) 226 German adults (66% women) who practiced NW regularly were interviewed during the winter 20032004. The average age was 52 yrs and BMI 25 kg/m^2. The main motivation for NW was health, 12% wanted to test something new, 6% did it as an option for cc skiing in summer. 71% worked out for arm and trunk muscles, 23% in order to reduce joint load. 54% would prefer to have a similar net of trails like those for hiking.

Nordic Walking has also been studied from the consumer perspective (Shove and Pantzar 2004). Authors conclude that popularity of the NW has arisen through the active and ongoing interaction of images, artifacts and forms of competence; a process in which both consumers and producers are involved.

Popularity of NW has been studied in Finland in two studies (National Exercise Study 20052006 by Suomen Kuntourheiluliitto, Nordic Walking survey 2006 in Finland by Suomen Latu).

In the National study phoneinterview based gallupsurvey done with 5500 Finns indicated NW being the second most popular activity mode among Finnish adults. Walking is the most popular (1 840 000 exercisers) activity. A total of 444 000 men and women of 1965year of age did nordic walking regularly in Finland 20052006, which places NW as the 7th most popular activity. The increase in nordic walkers in Finland since 20012002 was +144 000 adults (+48%), which makes NW the second largest activity in terms of growth.

In a NW survey published by Suomen Latu Association in 2006 1000 over 15 year old Finns were interviewed. According to the 2006 results the number of people experiencing Nordic Walking in Finland seems to remain in 1,5 million. 720 000 Finns do NW at least once a week; of them 39% are over 65year old. In the 2006 data 26% of adult women and 11% of adult men participated in NW regularly. The numbers indicate that NW has become more popular among men.

The different results of these two studies are explained by different form of questionnaires used.

Summary

To summarize the acute physiological effects of Nordic walking: it increases the energy consumption of the body compared to regular walking with the same speed without poles both in women and men of all ages and in fit and less fit individuals. The increase is due to larger working muscle mass in the upper body. The increase varies individually according to walking speed and technique. If the speed is very fast, there is less time for efficient pushing off with poles and thus decreased upper body muscular involvement. Similarly to energy consumption the increase in heart rate is variable. Because perceived exertion in pole walking is often less than true physiological strain, controlling heart rate may be beneficial for those tending to overreach. The resulting increases in energy consumption and heart rate in Nordic walking mean that the cardiovascular strain induced by Nordic walking is greater compared to walking without poles at the same speed. This is desirable for those people who have difficulty reaching their training heart rate by walking instead of having to start running they can start using walking poles and continue walking. Eventhough studies show some disagreement on biomechanical benefits of NW, it involves less harmful impacts to the lower extremities compared to running, and therefore may prevent from injuries.

To summarize, the training effects of Nordic walking on cardiorespiratory fitness and endurance have been shown to be similar to walking training in middleage and elderly women. In fit individuals and in men RCTtype intervention studies are missing. In the studies, the improvement in Nordic walking was reached by lower speed and thus by shorter distance walked, because the cardiovascular strain was greater in Nordic walking than in ordinary walking without poles if the same speed was used. Walking with poles improves mainly aerobic fitness, muscular endurance, decrease neckshoulder area disabilities and pain and can have positive effects on mood state. In order to improve muscle power, uphill walking is required. Little has been published on the effect of pole walking on body coordination and motor fitness. Nordic Walking is a safe activity and individuals are motivated to Nordic Walk mainly due health reasons.

Although there is rather strong scientific evidence on both acute and longterm effects of Nordic Walking some research challenges still remain. Ranzomized controlled trials on doseresponses of health and fitness improvements in men and in women, in the healthy, in the fit and in individuals with minor health problems (body weight, insulinresistance, blood pressure, osteoporosis) are still lacking. Additional biomechanical studies on NW effects on musculoskeletal health are needed. Also, studies in motivation and adherence in NW as well as overall global participation (walkers, their demographics and their socioeconomic status) in this activity are missing.

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