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Nordic walking versus natural walking: an easy approach to comparing metabolic demands

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ABSTRACT

The aim of this study was to compare the metabolic demands of Nordic walking (NW) versus natural walking (WK) using a highly reproducible protocol in a natural environment. A total of 14 physically active subjects (3 males and 11 females, 36.6 ± 8.3 years, 63.1 ± 11.4 kg, 1.67 ± 0.06 m) walked at a freely chosen speed along a 2.5-km course in a game reserve, using NW and WK in a random order. They were monitored for speed with a mobile phone global positioning system (GPS) receiver, and for lap average and maximum heart rate (HR) with a belt HR monitor. Analysis of variance (ANOVA) showed significantly higher lap average HR (p = 0.004) and maximum HR (p = 0.004) in NW compared with WK. Due to its increased metabolic load, NW revealed to be an effective means for improving cardiovascular fitness in populations with a low tolerance for exertion. Using this simple and ecological approach promises to be effective for further evaluation of other variables and/or use in other contexts (e.g. high altitude and climbing).

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Global positioning system; locomotion; physiological effort; sport science

1. Introduction

Nordic walking (NW) is a physical activity where specially designed poles are used to support the natural walking (WK) activity (Pellegrini et al., 2015). NW is one of a number of legged locomotion modes, such as WK, race-walking (Padulo, 2015) and running (Padulo, Chamari, & Ardigò, 2014). It is an increasingly popular exercise, with more than 7 million people involved in its practice in over 30 countries, and it is considered to be the fastest growing form of exercise in Europe (Pantzar & Shove, 2010). Previous studies demonstrated that NW can produce beneficial effects, both in the short and long terms, on maximum oxygen consumption (VO_{2max}), resting heart rate (HR), and exercise capacity, as reported in the systematic review of Tschentscher, Niederseer, and Niebauer (2013). The same review reported that the beneficial effects of NW were found both in healthy people and in subjects with major cardiovascular or metabolic

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diseases, including *diabetes mellitus*, obesity, hypertension, and peripheral artery diseases Tschentscher et al. (2013). Beneficial effects of NW were found in those suffering from Parkinson's disease as well (Monteiro et al., 2016). Such beneficial effects and the relatively easy and safe practice of this form of exercise make this activity a useful tool for improving physical fitness and preventing cardiovascular or metabolic diseases in populations with different characteristics. Probably for this reason, a number of studies have been performed in order to evaluate the effect of NW on physiological and psychological variables and its effectiveness in rehabilitation or in adapted physical activity programmes (Morgulec-Adamowicz, Marszałek, & Jagustyn, 2011). However, when analysing the literature, what is immediately apparent is the very large variety of contexts, protocols, and methods used in the different investigations concerning NW. Despite such heterogeneity of chosen approaches, investigations making use of a highly reproducible protocol in a natural environment are missing. Some studies focused on the metabolic expenditure of NW performed on different surfaces or with different pole lengths (Foissac, Berthollet, Seux, Belli, & Millet, 2008; Hansen & Smith, 2009; Schiffer, Knicker, Dannöhl, & Strüder, 2009). Other studies focused on the effects of NW on cardiovascular risk factors or on anthropometric and metabolic variables in individuals with type 2 *diabetes* (Fritz et al., 2013). Furthermore, other studies investigated the biomechanical aspects of this kind of activity (Hagen, Hennig, & Stieldorf, 2011). Regarding literature on this matter, a recent systematic review by Pérez-Soriano, Encarnación-Martínez, Aparicio-Aparicio, Giménez, and Llana-Belloch (2014) grouped the articles on NW into three categories: (1) articles concerning the body's physiological response (31% of the total articles), (2) articles investigating fitness programmes for improving people's health (45%), and (3) articles investigating biomechanical aspects (24%). However, this review concluded that despite the many articles published, many aspects of NW remain uncovered.

The prevalence of a perception of safety concerning the metabolic load during NW could be one of the reasons for its highly increasing popularity. The high metabolic expenditure caused by NW, combined with the low rate of perceived exertion, make this form of exercise a valid and versatile tool for improving cardiovascular fitness in all those people who have a low tolerance for exertion, whether they are healthy or suffer from a cardiovascular or metabolic disease. In fact, Hansen and Smith (2009) affirmed that the metabolic expenditure during NW performed on flat ground was 67% greater than in WK and that this metabolic expenditure could be further increased using a short pole length while walking uphill. Furthermore, Svoboda, Stejskal, Jakubec, and Krejčí (2011) demonstrated that the values of oxygen consumption and HR during NW were higher not only at 0% slope but also at 5% and 10% slopes, in comparison to walking without poles.

Yet, there is heterogeneity in the procedures, aims, and technologies used in the different articles that make it difficult to perform any comparison of the data and the results obtained. The opinion of the authors of this study is that the literature lacks an easy and highly reproducible protocol to test the metabolic demands of NW in a natural environment. Therefore, the aim of this study was to assess healthy adults simply (viz. naturally) walking and NW at freely chosen speed in a natural environment, in terms of HR and speed using a highly reproducible protocol. We hypothesised that (1) NW is more energetically demanding and (2) a highly reproducible protocol is effective enough to assess the two gaits.

2. Methods

2.1. *Participants*

For the sample size calculation, a pilot study that included a sample of 10 participants was performed a priori and gave a statistical power greater than 0.81. Therefore, 14 participants (3 males and 11 females; age = 36.6 ± 8.3 years; body mass = 63.1 ± 11.4 kg; body height = 1.67 ± 0.06 m; body mass index (BMI) = 22.3 ± 2.9 kg/m^2) volunteered for this study. None of the participants met the definition of "sedentary" as suggested by Pate, O'Neill, and Lobelo (2008), and consequently, they were classified as "physically active." To assure the safety of the participants during the trials and to avoid confounding influences on the results, the following exclusion criteria were used: medical contraindication or presence of a relevant disease incompatible with the proposed interventions (e.g. joint or mobility impairments); history of ictus, stroke, or other cardiopulmonary disease; presence of important risk factors for cardiovascular diseases; moderate or severe obesity (i.e. BMI > 30 kg/m^2; Shah & Braverman, 2012); and use of medications that influence HR or cardiovascular function.

Participants were asked to ensure that they received sufficient sleep on the night before the trial, to avoid severe exercise, and not to consume alcohol or energy drinks during the 24 hours before the experiment. The study was designed in conformity with the Declaration of Helsinki and was approved by the local ethical committee. All participants gave their informed written consent.

2.2. *Procedures*

All the participants underwent 2 weeks of familiarisation (two 2-h sessions per week) with WK and NW. After these 2 weeks, the 14 participants were asked to walk at a freely chosen speed in a game reserve, along a path of 2.5 km with a slope (Padulo et al., 2014) of between −1% and 1% (i.e. basically on flat dirt ground). Participants walked two laps, for a total of 5 km, using WK for one lap and NW for the other one. The order in which to perform the gaits was randomly assigned in order to have seven participants using WK in the first lap and NW in the second lap, and the other seven participants using NW in the first lap and WK in the second lap.

All the participants wore comfortable clothes and running shoes (category A3) and used poles (Stride X-R; Gabel, Vicenza, Italy). Length of the pole was determined by multiplying the height of the participant (in centimetres) by 0.68, rounded down to the nearest 5 cm within a tolerance of 2.5 cm, as recommended by the International Nordic Walking Federation (Pellegrini et al., 2015).

In order to evaluate the walking speed during the trials, each participant was monitored with a global positioning system (GPS) receiver (Ardigò, 2010; Ardigò & Capelli, 2012; Ardigò, Lippi, Salvagno, & Schena, 2011; Ardigò, Padulo, Zuliani A, & Capelli 2015; Fischer, Figueiredo, & Ardigò, 2015; Fischer, Tarperi, George, & Ardigò, 2014; Fuglsang, Padulo, Spoladore, Dalla Piazza, & Ardigò, 2017; Minetti, Formenti, &

Ardigò, 2006), namely, the one on an iPhone 6 (Apple, Cupertino, CA, U.S.A.) with Endomondo app (16.6.2; Under Armour, Inc., Baltimore, MD, U.S.A.; downloadable from https://www.endomondo.com/download; Hongu et al., 2014). A belt HR monitor (Suunto Memory Belt; Suunto Oy, Vantaa, Finland) was used to continuously assess and record HR during the trials. HR was normalised as percentage of maximum HR for each participant (HRmax, theoretically calculated using the formula "208–0.7 age in years"; Tanaka, Monahan, & Seals, 2001).

2.3. *Statistical analysis*

Multivariate analysis of variance (ANOVA) with repeated measured (RM-MANOVA) was used to evaluate whether significant differences existed between the two gaits relative to three analysed variables, as follows: average HR value during the lap (HR-av, measured as %HRmax), maximum HR value recorded during the lap (HR-peak, measured as %HRmax), and average speed to cover the lap (Speed, measured in km/h). The two gaits were used as within-participant factors for repeated measures analysis (two levels: WK vs. NW), whereas HR-av, HR-peak, and Speed were used as dependent variables. Alpha test level for statistical significance was set at $p < 0.05$. Effect size was calculated as partial eta squared (η_p^2). For these statistical analyses, the SPSS statistical package software was used (20.0; IBM, Chicago, IL, U.S.A.).

3. Results

RM-MANOVA showed significant differences between the two gaits ($F_{3,11} = 4.247$, $p = 0.032$, $\eta_p^2 = 0.537$). In particular, ANOVA with repeated measures showed significant differences in HR-av ($F_{1,12} = 11.778$, $p = 0.004$, $\eta_p^2 = 0.475$) and HR-peak ($F_{1,12} = 12.447$, $p = 0.004$, $\eta_p^2 = 0.489$), with higher values for NW than WK in both cases, as shown in Figure 1. No significant differences were found in the Speed variable (5.80 ± 0.48 km/h during WK and 5.82 ± 0.52 km/h during NW, $F_{1,12} = 2.167$, $p = 0.165$, $\eta_p^2 = 0.143$).

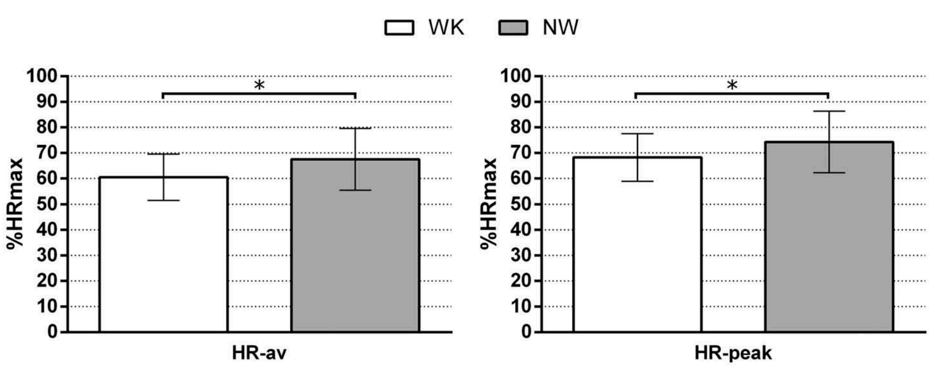

Figure 1. Nordic walking (NW) versus natural walking (WK) comparison in terms of lap average (HR-av, on the left) and maximum (HR-peak, on the right) heart rates, with both variables expressed as percentage of theoretical maximum heart rate (%HRmax). *$p < 0.05$.

4. Discussion

The main results of this study were the significant differences found between the two gaits in the variables related to HR (both HR-av and HR-peak), while a significant difference in Speed was absent. These results are in accordance with previous studies (Pellegrini et al., 2015; Tschentscher et al., 2013) indicating that NW requires a metabolic expenditure higher than WK, when these two gaits are performed under equal conditions. In particular, it was demonstrated that higher values of HR peak are found in NW compared to WK, as in this study (Church, Earnest, & Morss, 2002). Probably, the higher demand of metabolic expenditure is due to the contribution of the upper body muscles as required in NW (Tschentscher et al., 2013). In our study, one aspect worthy of consideration is that the participants did not decrease their speed during NW, despite their higher HR-av and HR-peak values. In other words, the participants did not reduce their physical activity level during NW, despite the higher metabolic expenditure. A priori, such a result could be explained with two hypotheses. The first hypothesis is that NW was not perceived as being more strenuous than WK. The second hypothesis is that the participants did not reduce their speed because NW was perceived as being safer and more "comfortable," despite the higher cardiovascular demand. By the way, such a hypothesis has already been documented in the animal reign and namely in running birds (Birn-Jeffery et al., 2014). Evidence from the literature supports the hypothesis that NW is not perceived as more strenuous than WK. In fact, the study of Church et al. (2002) affirmed that NW improved metabolic expenditure without significantly increasing the rate of perceived exertion. Similarly, the same conclusions were obtained by Barberan-Garcia et al. (2015), who demonstrated how NW enhanced oxygen uptake without increasing the rate of perceived exertion in patients with chronic obstructive pulmonary disease. Positive effects were also observed in a study on patients with peripheral arterial disease (Oakley, Zwierska, Tew, Beard, & Saxton, 2008). NW enabled such patients, with intermittent claudication due to their pathology, to walk further with less pain, despite a higher workload. Similar function improvements were observed in participants with Parkinson's disease as well (Monteiro et al., 2016).

The limit of this study is that HR is only a proxy for the metabolic demand. HR measure is easy, and this easiness generally prompts towards HR-based investigations. Such researches are easily reproducible by other scientists or simply interested people. The gold standard for short- to middle-term metabolic demand estimate is the VO_2 consumption measure. Furthermore, HR might be affected by many confounding variables, especially during NW, where arm movement is present and could stimulate sympathetic drive without any corresponding metabolic demand response.

5. Conclusions

This study highlighted the relevant metabolic expenditure due to NW with an easy and highly reproducible procedure performed in a natural environment. The approach used was chosen and adopted in order to (1) estimate HR demand during the investigated gaits in an ecological setting, while (2) keeping it as easy and effective as possible in order to enable further evaluation of other variables and/or to be used in other contexts (e.g. high altitude and climbing). In fact, in a natural environment, there are different variables that can influence the metabolic expenditure, such as the type of surface (Schiffer et al., 2009), and this is the reason why the authors of this study decided to perform the trials in a game reserve. The advantage of this choice is that it will allow a comparison of this study's findings with the results of future investigations. Indeed, other variables need to be evaluated in order to obtain more clear and accurate indications about the usability and potential risks of NW compared to WK, such as the influence of weather conditions and/or ground compactness, which are not reproducible in a research setting.

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