



Original Article

Trekking poles reduce downhill walking-induced muscle and cartilage damage in obese women

SU YOUN CHO¹⁾, HEE TAE ROH^{2)*}

¹⁾ Exercise Physiology Laboratory, Department of Physical Education, Yonsei University, Republic of Korea

²⁾ Department of Physical Education, College of Arts and Physical Education, Dong-A University:
37 Nakdong-daero, 550 beon-gil, Hadan-dong, Saha-gu, Busan 604-714, Republic of Korea

Abstract. [Purpose] This study investigated the effect of the use of trekking poles on muscle and cartilage damage and fatigue during downhill walking in obese women. [Subjects and Methods] Subjects included eight obese women who had a body fat percentage greater than 30. Subjects performed downhill walking without a trekking pole (NP) and with a trekking pole (TP) at 50% heart rate reserve for 30 minutes on a treadmill. The treadmill was set at a 15% downhill declination. Blood samples were collected to examine muscle damage (serum creatine kinase [CK] and lactate dehydrogenase [LDH] levels), cartilage damage (serum cartilage oligomeric matrix protein [COMP] levels), and fatigue (plasma lactate levels) at the pre-walking baseline (PWB), immediately after walking (IAW), and 2 hours post-walking (2HPW). [Results] The CK, LDH, COMP, and lactate levels were significantly increased IAW when compared with those at the PWB in both trials. In addition, in the NP trial, the CK, LDH, and COMP levels were significantly increased at 2HPW when compared with those at the PWB. [Conclusion] Downhill walking can cause muscle and cartilage damage, and our results suggest that the use of a trekking pole can reduce temporary muscle and cartilage damage after downhill walking.

Key words: Trekking pole, Muscle damage, COMP

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INTRODUCTION

Walking is one of the recommended modes of exercise for obese individuals because of its merits in terms of safety, accessibility, and popularity, as well as proven efficacy in weight management^{1, 2)}. However, walking over a terrain of repetitive uphill and downhill inclines in activities such as mountain climbing can cause excessive fatigue and muscle damage³⁾. In particular, repetitive eccentric contractions of the lower limb muscles during downhill walking places sarcomeres under excessive tensile stress. This stress can destroy sarcomeres by extending them beyond their normal length, sometimes involving a local inflammatory reaction, and can thereby lead to delayed onset muscle soreness or exercise-induced muscle damage. The indexes reflecting such conditions are serum creatine kinase (CK) and lactate dehydrogenase (LDH) levels^{4, 5)}. It has been reported that the use of a pole during walking over an uneven terrain could improve gait stability and balance, and that its use during downhill terrain walking can reduce the load and stress on the lower limbs (such as the ankle, knee, and hip joints)^{6–8)}. However, previous studies on the effects of a pole during downhill walking have been limited to the kinetic aspects such as the reduction of knee joint forces or the load on the lower extremity joints.

Meanwhile, it has been suggested that increases in peripheral cartilage oligomeric matrix protein (COMP) levels after exercise could serve as a biomarker of cartilage degradation and damage⁹⁾, and Pruksakorn et al. reported significant increases in serum COMP levels after uphill walking¹⁰⁾. In addition, according to a comparative study by Andriacchi et al. that measured the maximum flexion of the lower extremity joints during various routine activities, the flexion of the knee joint was approximately 4 times greater during walking down stairs than during walking over level ground¹¹⁾. Taken together, such previous reports suggest that the use of a pole during downhill walking may alleviate the burden on lower extremity joint

*Corresponding author. Hee Tae Roh (E-mail: dau0409@dau.ac.kr)

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cartilages; however, thus far, there has been no report examining this potential benefit.

Accordingly, this study aimed to investigate the effect of the use of a trekking pole on muscle and cartilage damage and fatigue during downhill walking. The study specifically examined obese women who had less muscle mass than men and whose heavy weights were likely to increase the burden on their lower limb muscles and joints during walking.

SUBJECTS AND METHODS

Eight obese women (average age of 21.1 ± 1.8 years, average height of 164.8 ± 4.9 cm, average weight of 61.8 ± 7.7 kg, average body fat percentage of $33.9 \pm 1.4\%$, and average resting heart rate of 69.6 ± 3.7 beats/min) with body fat percentages ranging from 30.0 to 36.1 volunteered as subjects for this study. The study conformed to the standards set by the latest revision of the Declaration of Helsinki, and all subjects read and signed a written informed consent statement consistent with the guidelines of the Department of Physical Education at Yonsei University.

Anthropometric measurements included height, body composition, and resting heart rate. Height and body composition were measured using a stadiometer (SECA213; SECA, Hamburg, Germany) and a bioimpedance analysis (BIA) device (Inbody720; Biospace, Seoul, Korea), respectively. Resting heart rate was measured in a seated position using a heart rate monitor (Polar a5; Polar, Kempele, Finland).

Each of the eight subjects participated in a total of two trials: one NP trial (walking without using a trekking pole), and one TP trial (walking using a trekking pole). With the treadmill angle set to a decline of 15% based on a study by Perrey and Fabre¹²⁾, the participants were subjected to 30 minutes of walking at an exercise intensity of 50% of their heart rate reserve. The experiment used a crossover design to minimize the adaptation from the repetitive exercise trials, and each trial was separated by 7 days to avoid any transient effects on the physiological and psychological conditions of the subjects. An adjustable-length trekking pole (6342011; LEKI, Hamburg, Germany) was used, and the length was initially set at 70% of the user's height so that the elbow angle was maintained at 90° when the user was standing on level ground. When the pole was used for downhill walking, its length was increased by approximately 5 cm.

Using a 22-gauge needle, a serum separator tube (Becton Dickinson, Franklin Lakes, NJ, USA), and a ethylenediamine tetra-acetic acid tube (Becton Dickinson), 7 ml of blood was collected from the antecubital vein of each subject at the pre-walking baseline (PWB), immediately after walking (IAW), and 2 hours post-walking (2HPW). Collected blood samples were centrifuged for 15 minutes at 3,000 rpm and then stored at -80°C until analysis. The serum CK and LDH levels were determined using a clinical chemistry analyzer (Ektachem DTSCII; Eastman Kodak, Rochester, NY, USA). The serum COMP levels were determined with an enzyme-linked immunosorbent assay (ELISA) using a commercially available Human COMP[®] ELISA kit (AnaMar AB, Lund, Sweden). The absorbance was measured at 450 nm with a microplate reader (Molecular Device, Palo Alto, CA, USA). The plasma lactate levels were determined using a clinical chemistry analyzer (Ektachem DT 60; Eastman Kodak, Rochester, NY, USA).

Statistical analyses were performed with SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA). Data are presented as the mean \pm standard deviation (SD) unless otherwise stated. For identifying differences in normally distributed results, two-way repeated analysis of variance (ANOVA) was employed. When significant group by time interactions occurred, simple main effects were assessed using one-way ANOVA and independent t-tests. Levels of significance were set at $p=0.05$.

RESULTS

The biomarker levels measured are presented in Table 1. The serum CK, serum LDH, serum COMP, and plasma lactate levels were significantly increased IAW when compared with those at the PWB in trials NP and TP ($p<0.05$). In addition, in trial NP, the serum CK, serum LDH, and serum COMP levels were significantly increased at 2HPW when compared with those at the PWB ($p<0.05$).

DISCUSSION

Exercise-induced muscle damage increases in situations involving eccentric muscle contractions, such as during downhill walking and/or running⁴⁾. Increases in serum COMP levels reflect cartilage degradation and damage after acute exercise⁹⁾. This study measured the levels of serum CK, LDH, and COMP to investigate the effect of the use of a trekking pole on muscle and cartilage damage during downhill walking. The results demonstrated that the levels of CK, LDH, and COMP were significantly higher IAW and 2HPW than at the PWB in the case of the NP trials. In the case of the TP trials, however, the levels 2HPW were significantly lower than those for the NP trials and actually returned to their level at the PWB. The rationale could be that the use of a trekking pole alleviated the temporary muscle and cartilage damage induced after downhill walking. This result is in accordance with those of previous studies; Howatson et al. showed significantly lower serum CK levels at 24 hours after mountain climbing in an experimental group that used trekking poles than in the control group, suggesting that the use of trekking poles could alleviate muscle damage during recovery³⁾. In addition, exercise-induced increases in joint load have been shown to cause a temporary increase in serum COMP levels after walking or running by promoting catabolism, in particular, in cartilages such as the articular cartilage in the knee^{9, 13)}. Bohne and Abendroth-Smith suggested that the use of a trekking pole during downhill walking could be effective for reducing such loads on the lower

Table 1. Peripheral biomarkers after downhill walking with the use of trekking poles (TP) and without their use (NP)

Variable	Trial	PWB	IAW	2HPW
CK	NP	260.3 ± 39.1	349.1 ± 37.9*	302.9 ± 42.0*
(U/l)	TP	256.1 ± 42.0	312.5 ± 44.9*	270.9 ± 34.5
LDH	NP	351.5 ± 77.8	453.4 ± 70.6*	377.0 ± 84.0*
(U/l)	TP	354.9 ± 79.3	385.1 ± 71.2*	363.5 ± 64.6
COMP	NP	9.6 ± 2.0	13.6 ± 3.8*	12.0 ± 2.8*
(U/l)	TP	9.9 ± 2.2	13.2 ± 3.6*	10.0 ± 2.1
Lactate	NP	1.4 ± 0.6	4.2 ± 1.2*	1.6 ± 0.6
(mmol/l)	TP	1.5 ± 0.5	4.1 ± 0.6*	1.6 ± 0.9

Data are presented as mean ± SD. NP: no trekking pole trial; TP: trekking pole trial; PWB: pre-walking baseline; IAW: immediately after walking; 2HPW: 2 hours post-walking; *p<0.05 vs. PWB.

extremity joints⁷). According to the results of some previous studies, the use of a trekking pole could reduce lower limb joint forces by as much as 25%, enabling a 13 kg reduction of load per stride during downhill walking^{3, 14}).

However, as for the plasma lactate levels in this study, no significant difference was observed with the use of a trekking pole. The rationale is that although the use of a trekking pole reduced forces on the lower limbs, it increased the activity of the upper limbs and consequently maintained a similar fatigue level in the whole body. This interpretation is supported by the report that plasma lactate concentration was a biomarker reflecting peripheral muscle fatigue during exercise¹⁵), as well as by the suggestion of Fritschi et al. that, although the use of a pole during walking could reduce vertical knee joint forces, it could increase upper limb muscle activation¹⁶).

In conclusion, downhill walking can cause muscle and cartilage damage, and it is suggested that the use of a trekking pole can reduce temporary muscle and cartilage damage after downhill walking.

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