The Metabolic Cost of Carrying a Single- versus Double-Strap Golf Bag

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Abstract

The purpose of this study was to compare energy expenditure and perceived comfort using two modes of carrying a golf bag. Fifteen men completed 2 trials of walking on a treadmill while carrying a golf bag. During 1 of 2 trials, an extra strap was added to convert a single-strap bag to a double-strap bag. The order was randomized. Oxygen consumption ($L \cdot min^{-1}$), heart rate, perceived exertion, and perceived comfort were measured during the 5-minute walk. Oxygen consumption was significantly lower carrying the double-strap golf bag ($L \cdot min^{-1}$, $p = 0.0004$; $ml \cdot kg^{-1} \cdot min^{-1}$, $p < 0.0003$), as were heart rate ($p = 0.0013$) and rate of perceived exertion ($p < 0.005$) During the double strap trial, the perceived comfort was higher ($p < 0.005$). Improvements in metabolic demands and comfort while carrying a double-strap golf bag should increase walking tolerance in golf.

Key Words load carriage, metabolic demand, walking

Introduction

According to the National Golf Foundation, the number of "core" golfers in the United States was 12.8 million in 2004, and there were an additional 14.6 million occasional golfers (11). The benefits of golf include improved aerobic conditioning, trunk muscle strength, body composition, and serum lipids (14). These benefits have been largely attributed to walking. Leiker and Kandt (6) found that playing an 18-hole golf course required nearly 6 miles of walking and over 13,000 steps for 15 women golfers. Golf is widely accepted as a low risk sport (1), and it has been recommended by physicians after hip and knee arthroplasty (10).

However, a golf bag filled with a set of clubs provides a substantial load. Carried over a distance, this load can increase metabolic demands beyond tolerance for some people. From analysis of a survey of 528 golfers, Theriault et al. (16) reported that there was a significant difference in perception of fatigue following a day of golf in golfers who reported injuries. If injuries, discomfort, or fatigue lead to using a golf cart, then the health benefits attributed to walking may be lost.

The optimal mode of carrying a load should increase the body's stability, have the load close to the center of mass (COM) and use muscles of large mass (4). Traditional golf bags are designed with one strap and the bag is carried over one shoulder, thus the load is close to the COM, but it is asymmetrical.

Malhotra and Sen Gupta (9) reported that asymmetric carrying of a rucksack increased minute ventilation, VO_2, and heart rate in school children. Carrying the rucksack with two straps was the most efficient mode, while carrying a load slung across one shoulder resulted in an 83% increase in energy consumption. Legg et al. (6) also found a significant difference in the metabolic cost of soldiers carrying asymmetric loads on the shoulders versus carrying a backpack. Based on the percent of maximum oxygen uptake, the authors concluded that the soldiers would probably tolerate the backpack condition for longer periods of time. Lloyd and Cooke (8) found lower metabolic costs for carrying a backpack that contained front balance pockets, more evenly distributing the load in the sagittal plane.

The higher metabolic costs associated with asymmetrical loading could be due to several factors, including alteration in gait efficiency and increased muscle activation. Pascoe et al. (15) found alterations in head, shoulder, and trunk posture with children carrying one- versus two-strap backpacks. Fowler et al. reported a lateral bending of the lumbar spine away from the load and a forward bending of the thoracic spine during walking with a mail bag over one shoulder (4). Neumann (12) reported that loads held in the contralateral hand of subjects with hip prostheses produced greater hip abductor electromyographic (EMG) activity, as compared to unloaded ambulation. In contrast, loads held in the ipsilateral hand demonstrated lower EMG activity.

Although slung over one shoulder, the traditional golf bag is positioned across the back, thus distributing a portion of the load across midline. The Loop (Sun Mountain Sports, Missoula, MT) is a simple band that fastens to the existing strap attachment and converts a golf bag to a double-strap design. This device loads both shoulders like a back pack, but

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Table 1. Oxygen consumption ($L \cdot min^{-1}$), oxygen consumption by body weight ($ml \cdot Kg^{-1} \cdot min^{-1}$), and heart rate during 5-minute walk under single- and double-strap conditions.

	Single-Strap Bag		Double-Strap Bag		ANOVA
	Mean ± *SD*	Range	Mean ± *SD*	Range	*P*
VO_2	1.18 ± 0.14	0.84–1.42	1.10 ± 0.84	0.86–1.30	0.0004
$ml \cdot Kg^{-1} \cdot min^{-1}$	15.27 ± 1.52	12.02–17.87	14.18 ± 1.18	12.30–16.37	0.0003
HR	104.1 ± 9.7	91–128	101.4 ± 11.0	82–126	0.0013

the load distribution is not necessarily equal due to the relatively superior location of the attachment to the bag. To our knowledge, no study has examined the energy consumption related to the carrying of a golf bag with one versus two straps. The purpose of this study was to determine if there was a significant difference in oxygen consumption, perceived exertion, and perceived comfort between walking with a one- or a two-strap golf bag.

Methods

Experimental Approach to the Problem

The authors could find no previously published literature addressing carrying modes of golf clubs. Carrying a backpack with one strap changes the load position, but use of a double strap did not change the position of the golf bag relative to the golfer. Treadmill testing was selected to minimize the effect of varying ground conditions that could affect postural adjustment and load shift. Young healthy men were chosen as subjects to avoid factors such as deconditioning or preexisting pathology that could affect oxygen consumption.

Subjects

Fifteen healthy men between the ages of 20 and 48 (age, 27.5 ± 7.2 years) participated in this study. Subjects with a history of back or lower extremity pathology or impairments were excluded from the study. Prior to participation, the subjects read and signed a written informed consent that

Figure 1.

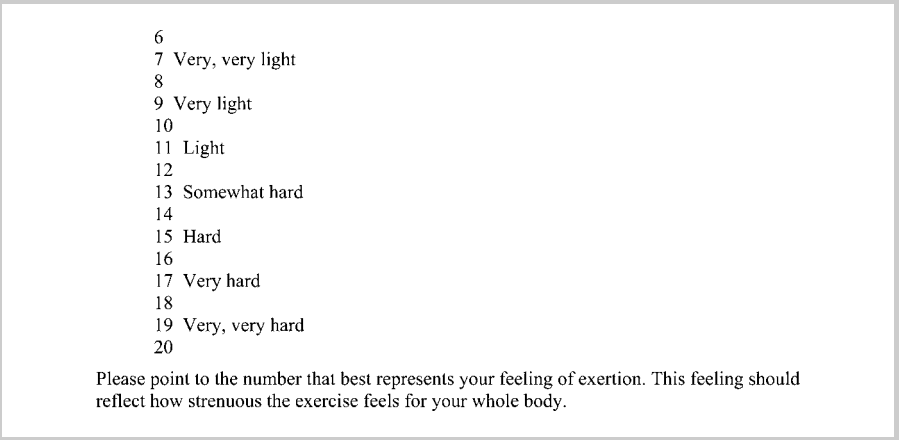

Figure 2. Borg's rating of perceived exertion.

was approved by the University of Montana Institutional Review Board.

Procedures

The equipment, which consisted of a single-strap golf bag with a standard set of clubs weighing 28 pounds, and the Loop device, were adjusted for each subject so that the golf bag hung across the low back for both the double-strap (DS) and single-strap (SS) trials (Figure 1). The single strap was placed over the right shoulder. The subjects were randomly assigned to the mode of initial testing. A heart rate monitor was placed around the chest at the xyphoid process (Polar, Port Washington, NY). A nose clip and mouthpiece were placed on each subject to collect expired gases. The subjects sat quietly for 2 minutes while baseline heart rate was recorded. The subjects then walked with the golf bag for 5 minutes on the treadmill (Quinton Q65, Seattle, WA) at 3.0 miles per hour with a 2% grade. Oxygen consumption was collected at 20-second intervals during the last 2 minutes using a TEEM 100 metabolic system (AeroSport, Ann Arbor, MI). At the end of the test, heart rate was recorded, the subjects were asked to rate their exertion on a Borg Scale (Figure 2) and their level of comfort was documented on a visual analog scale (Figure 3). The subjects were allowed to rest for at least 5 minutes, or until their heart rate was within 8 beats of baseline. The test was then repeated with the alternate mode of carrying the golf bag and clubs.

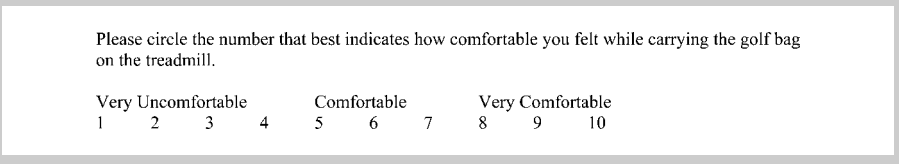

Figure 3. Visual analogue scale for discomfort.

Statistical Analyses

Relative oxygen consumption ($ml \cdot 5g \cdot min^{-1}$) was calculated using VO_2 and body weight. Mean values for oxygen consumed ($L \cdot min^{-1}$), VO_2 $ml \cdot kg \cdot min^{-1}$, heart rate (HR), rate of perceived exertion (RPE), and visual analogue scale for comfort (VAS) were calculated. The objective dependent variables (VO_2, VO_2 $ml \cdot kg \cdot min^{-1}$, and HR) were analyzed using a one-way repeated measures ANOVA. Subjective dependent variables (RPE and VAS) were analyzed using Wilcoxon Signed-Ranks test. Alpha levels of 0.05 were used for significance.

Results

The mean, standard deviation, and range of VO_2, $ml \cdot kg^{-1} \cdot min^{-1}$, and HR, RPE, and VAS are presented in Table 1 for both SS and DS trials. The DS carrying mode required significantly less oxygen consumption: $L \cdot min^{-1}$, $p < 0.0004$; VO_2 $ml \cdot kg^{-1} \cdot min^{-1}$, $p < 0.0001$, heart rate was lower, $p < .0013$, and subjects reported significantly lower RPE ($T = 4.5$, $p < .005$) and comfort level, as measured by VAS, was greater, ($T = 0$, $p < .005$).

Discussion

This study demonstrated significant decreases in perceived exertion and metabolic costs (as measured by RPE, HR, and VO_2) when carrying a two-strap golf bag and clubs versus the same bag with one strap. These findings are consistent with previous studies that examined symmetrical and asymmetrical carrying in children and soldiers (6,8,9). In addition, subjects in this study reported more comfort with the load distribution across both shoulders in the two-strap condition.

An asymmetrical load will alter the relationship of the COM to the base of support, creating a sidebending moment that requires muscle activation to maintain the upright position. Cook and Neumann (2) found increased muscle activation in the contralateral paraspinals when carrying a load on one side. This increased muscle activity creates a higher demand on the cardiorespiratory system. In addition to improving the symmetry of the load, the double strap system may also increase the stability of the golf bag, requiring less muscle activity to limit sway. Lower metabolic

costs and increased comfort may facilitate the ability to play golf for longer periods of time without fatigue.

Less fatigue using the double-strap system may lead to fewer injuries. Theriault et al. (15) found that golfers with injuries reported a perception of fatigue following a day of golf significantly more often than those without injury. The injuries were in the spine (39.7%), the upper limbs (42.4%), and lower limbs (17.9%). Noone et al. (14) proposed that asymmetric loading causes lateral bending of the spine to move the center of mass over the base of support. This alters joint mechanics but has the effect of reducing the increase in muscle activity required to maintain equilibrium. Without this compensation, the metabolic demands could be even higher. Unfortunately, these asymmetric loads can increase shearing force at the joint, add stress to supporting ligaments, cause forces to be distributed over a smaller surface area, and increase compressive forces by contracting muscle. In addition to acute injuries, mechanical alterations such as these may lead to, or aggravate, osteoarthritis (1). A combination of increased metabolic demands and poor mechanics may predispose golfers to injury. Using the double-strap golf bag may ameliorate these effects.

Practical Applications

The subjects in this study were young and walked only 5 minutes on a treadmill. The authors anticipate that the beneficial change in metabolic costs, perceived exertion, and comfort would be greater with older people walking on uneven ground over an entire golf course. This would allow them to play longer or have more energy for other activities. Walking with less fatigue and more comfort may influence the decision to use a golf cart, which negates many of the beneficial aspects of walking. In addition, less fatigue and more symmetry may reduce the risk of injury and may improve performance.

Golfers who desire to increase metabolic demands to improve fitness or assist in weight loss may choose to use a single-strap bag. However, they should consider the additional mechanical stresses that may lead to musculoskeletal damage.

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