Comparative effectiveness of playing golf to Nordic walking and walking on acute physiological effects on cardiometabolic markers in healthy older adults: a randomised cross-over study

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ABSTRACT

Objectives The acute effects of aerobic exercise on cardiometabolic markers are well documented in younger healthy individuals, but the same effects in older adults have not been elucidated. As such, this study compares the acute effects of three different types of age-appropriate aerobic exercises on cardiometabolic markers.

Methods Healthy older golfers (n=25, 16 male and 9 female, 68±4 years) were enrolled in a randomised cross-over experiment. We compared the effects of three different acute aerobic exercises (18-hole golf, 6km Nordic walk, 6km walk) on blood pressure, blood glucose and blood lipid profile in a real-life environment.

Results In the between-group comparison, playing golf resulted in a difference in blood glucose (golf: 0.01±0.1 mmol/L, walk: 1.3±0.9 mmol/L, p<0.001) compared with walking and triglycerides (golf: 0.13±0.2 mmol/L, Nordic walk: 0.31±0.2 mmol/L, walk: 0.23±0.2 mmol/L, p=0.012) and high-density lipoprotein cholesterol (golf: 0.04±0.06 mmol/L, Nordic walk: −0.02±0.06 mmol/L, walk: −0.02±0.07 mmol/L, p=0.002) compared with Nordic walking and walking. In addition, all groups had significant decreases (p<0.001) in systolic blood pressure, and Nordic walking and walking also demonstrated a decrease in diastolic blood pressure (p<0.05).

Conclusion Acute bouts of aerobic exercise improved cardiovascular profile in healthy older adults. Despite the lower exercise intensity of golf, the longer duration and higher energy expenditure appeared to have a more positive effect on lipid profile and glucose metabolism compared with Nordic walking and walking.

Trial registration number ISRCTN10007294.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The acute effects of aerobic exercise and exercise-specific effectiveness on cardiometabolic markers in healthy older adults are unknown.

WHAT THIS STUDY ADDS

⇒ These findings represent the first scientific data on the acute effects of playing golf in healthy older adults compared with Nordic walking and walking.

⇒ Playing golf affects plasma lipid profile and glucose metabolism more positively than Nordic walking and walking.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings could help to elucidate the exercise-specific effectiveness of different types of age-appropriate aerobic exercise on cardiovascular disease risk factors. The study can, therefore, recommend exercise as a preventive factor for older adults and offers treatment strategies to improve cardiometabolic health in older adults who likely already have cardiovascular diseases.

INTRODUCTION

Cardiovascular diseases (CVDs) remain the leading cause of rising health costs and mortality among the elderly. Sedentary behaviour and physical inactivity are particularly emphasised as major modifiable cardiometabolic markers, which are reflected by the increased prevalence of hypertension, diabetes and dyslipidaemia in older adults.

CVDs can be prevented by controlling key determinants of cardiometabolic markers, such as blood pressure (BP), blood glucose (BG) and lipids, through lifestyle modifications like exercise. Acute aerobic exercise (AE) on lipid profile, BP and BG has been shown to reduce cardiometabolic markers and improve cardiovascular health. However, most related studies have been restricted to younger individuals in clinical trials with an acute bout of exercise lasting 30–60 min at moderate to high intensity (VO2max 40%–75%) exercise. Furthermore, it seems that the effects of acute exercise on...
these key determinants vary depending on the exercise’s type, intensity and duration.\textsuperscript{6,15,16}

Especially in the ageing population, which has an increased risk of CVDs, a better understanding of the exercise-specific effectiveness of different types of age-appropriate AE on cardiometabolic markers is necessary to recommend exercise as a preventive factor and a treatment strategy.\textsuperscript{1,2} Golf, Nordic walking and walking are popular age-appropriate forms of outdoor AE which can be considered safe and accessible for older people.\textsuperscript{15–17}

This study investigated whether a single bout of three different types AE in terms of intensity, duration and energy expenditure (golf, Nordic walking, walking) affects the following cardiometabolic markers: systolic BP (sBP); diastolic BP (dBP); BG and lipid levels such as total cholesterol (TC), triglycerides (TGs), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C).

METHODS

Study design

The study was designed as a 5-day randomised crossover study. Healthy older golfers (n=25) completed three different exercise trials in a real-life environment, in random order and at a self-selected pace. The exercises included an 18-hole golf round in Tarina Golf’s old course (course profile: flat; length from red tees: 4477 m) by pulling-a-trolley walking in 2–3-player groups and predetermined walking routes (profile: flat; length: 6000 m) for Nordic walking and walking. The study protocol is presented in figure 1. Participants were divided for two separate weeks. In addition, using a crossover design, participants were randomly divided into three groups (n=4–5), which participated in the exercise trials over a 5-day study protocol. For example, the golf group started with an 18-hole golf round on the first day (d1), then completed Nordic walking on the third day (d3) and finished with walking on fifth day (d5). On the second (d2) and fourth (d4) days, there was a 1-day wash-out phase between each exercise trial to minimise any carryover effect of training. All participants were asked to maintain their regular physical activities and nutritional habits and to report these by diary during the 5-day period.

Participants

Healthy golfers (> 65 years, body mass index (BMI)<35 kg/m\(^2\), golf handicap (HCP) ≤ 36, plays at least 18 holes once a week) were recruited from Tarina Golf’s (Siilinjärvi, Finland) official membership register. Recruitment occurred in August 2021; 60 volunteers (n=60) were interested in participating and 34 were recruited for the screening test. Inclusion criteria were male or female, > 65 years of age and BMI <35 kg/m\(^2\). Exclusion criteria were diagnosis of dementia, Alzheimer’s disease, Parkinson’s disease and CVDs. Long-term use of hyperlipidaemia and hypertension medication was allowed except for medication that might affect heart rate (HR), such as beta-blockers. The volunteers were measured at the University of Eastern Finland (Kuopio, Finland) for weight, height and body composition were registered using bioimpedance measurement (Inbody 720 1996),\textsuperscript{18} while waist and pelvis circumference and BP were measured using Omron M6AC.\textsuperscript{19} In addition, an Urho Kaleva Kekkonen (UKK) 6 min walking test\textsuperscript{20} was conducted to measure cardiorespiratory fitness, and a short physical performance test\textsuperscript{21} was used to monitor physical function. Volunteers’ health status and suitability for the study were evaluated by a doctor, and 26 participants were ultimately deemed eligible for the study.

Sample size

The required calculation of the sample size was performed for the main outcome variable of BG. Based on at least 21 participants, walking and golf have a significant statistical difference (p<0.05), assuming a BG concentration of 5.8 mmol/L after golf, 6.4 mmol/L after Nordic walking and 6.4 mmol/L after walking. The SD is 0.7.

Experimental protocol

The experimental protocol is presented in figure 2. On experimental days, participants arrived at Tarina Golf Course (Siilinjärvi, Finland) at 7:00 hours following an overnight fast (<10 hours). First, blood samples and a BG finger-prick test were taken. Next, non-invasive BP was double-measured using a mercury sphygmomanometer\textsuperscript{10} in a sitting position. Then, the participants were fitted with a FitBit Versa 3 on the wrist (USA)\textsuperscript{22,23}—a device to measure exercise-specific distance, duration, pace, energy expenditure and steps. They were also fitted with a Beat2Phone ECG sensor with a chest strap (Vital-Signum, Finland)\textsuperscript{24,25} to measure HR. Following blood samples and BP tests, food was controlled by having the participants consume a standardised breakfast (530 kcal) before the exercise and a snack (150 kcal) during the golf round. One hour after breakfast, each participant

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*Figure 1* Flow chart of study design.
started the exercise trial. Participants were instructed to
maintain a pace corresponding to a brisk walking speed
during each exercise modulate. After the exercise modulates, the measurements were repeated immediately
(<15 min). Participants were supervised to ensure consistent
behaviour across each of the study trials. In addition, the
estimated HR max was calculated as 220 bpm—age
during each trial.

Blood samples
Blood samples were drawn from the brachial vein after
an overnight fast (10 hours) before and after the exer-
cise. Participants were instructed to avoid caffeine,
alcohol or physical activity the day before the sampling.
Blood samples were collected into Li-heparin tubes for
tC, HDL-C, LDL-C and TGs and EDTA tubes for haemo-
globin A1c (HbA1c). HbA1c was measured only once
before the first morning of the trial. BG was collected
using a finger-prick test (Roche, Indianapolis, USA).26
The samples were delivered to a laboratory (ISLAB, KYS,
Kuopio, Finland) on the same days as the trials. The concentration of tC, HDL-C, LDL-C, TGs and HbA1c was
determined according to the manufacturer’s instructions
(cobas 8000 (c 702)—analyser, Hitachi High Technology,
Tokyo, Japan). Coefficient of variation for interassay of
lipid analysis were less than 2.0% using reagents of the
cobas c 702 systems (Roche Diagnostics, Mannheim,
Germany).

Statistical analysis
All data were analysed using IBM SPSS Statistics V.27.0
(IBM). The Mann-Whitney U test was also used to
compare the exercise-specific outcomes between
genders. The Wilcoxon signed-rank test was used to
compare cardiometabolic marker outcomes within-
group pre-exercise and postexercise session. Due to these
markers, the wash-out phase was calculated between day
1 and day 3. Due to the rather small sizes of the groups,
the Kruskal-Wallis test was used to assess differences
between outcomes in all three groups at baseline and
their changes during the trial period. Significant interac-
tion effects of within-subject factors were further analysed
using the pairwise comparison, and the Kruskal-Wallis H

test was used with post hoc. The significance level was set
to p<0.05, and the CI limits were 95%.

RESULTS

Characteristics of study participants
Following the withdrawal of one participant, 25 partici-
pants (68±4 years; 16 (64%) males and 9 (36%) females) were eligible for the study. All participants engaged in
each exercise modulate, with the exception of one person
who did not complete the golf round due to health issues.
The characteristics of the subjects are shown in table 1.
The study participants had a mean age of 68±4 years, an
HbA1c of 37.4±5.6 mmol/L and a VO2max of 33±4 mL/kg/
min. Most participants were normal weight to overweight
(25±2.5 kg/m²) and had elevated BP (144/89±18/12 mm
Hg) and increased TC (5.5±1.2 mmol/L).

Acute responses to exercise-specific outcomes
The responses in exercise-specific outcomes are shown
in table 2. The exercise-related outcomes of distance
(p<0.001), time (p<0.001), steps (p<0.001) and energy
expenditure (p<0.001) were significantly greater for
golf compared with both Nordic walking and walking.
However, the average HR of golf (p=0.050) was signifi-
cantly lower. In addition, the only difference between
genders was found in energy expenditure in golf
(p=0.032) and walking (p=0.010) as men reported higher
values. The average exercise intensity during each trial
was 61% in the golf group, 77% in the Nordic walking
group and 76% in the walking group.

Acute responses to BP, BG and lipid levels
Participants’ acute responses to golf, Nordic walking and
walking in terms of BP, BG and lipid levels are shown in

table 3. Decreased sBP postexercise was observed in all
groups (golf: p<0.001, Nordic walking: p<0.001, walking:
p<0.001), while decreased dBP was found in the Nordic
walking (p=0.038) and walking (p=0.022) groups. TC did
not change throughout the study for the golf (p=0.152)
or Nordic walking (p=0.126) groups, but it decreased
slightly postexercise in the walking group (p=0.034). TG
concentrations increased postexercise in all groups (golf:
p<0.003; Nordic walking: p<0.001, walking: p<0.001).
Similarly, LDL-C concentrations decreased slightly
postexercise (golf: p<0.023; Nordic walking: p<0.019,
walking: p<0.036). An immediate increase occurred only
with HDL-C in the golf group (p=0.002). In addition,
BG levels increased in the Nordic walking (p=0.003) and
walking (p<0.001) groups, while the golf group main-
tained steady BG levels. However, we found that the
golf group had significant differences in BG compared
with the walking group (golf: 0.01±1.0 mmol/L, walking:
1.3±0.9 mmol/L, p<0.001) and TGs (golf: 0.13±0.2 mmol/L,
Nordic walking: 0.31±0.2 mmol/L, walking: 0.23±0.2 mmol,
p=0.012) and HDL-C (golf: 0.04±0.06 mmol/L, Nordic walking:
−0.02±0.06 mmol/L, walking: −0.02±0.07 mmol/L, p=0.002) compared with
Nordic walking and walking. Data from the wash-out

Figure 2 Flow chart of experimental day protocol.
period between d1 (pre-exercise) and d3 (pre-exercise) are presented in Table 4. Only the golf group demonstrated a significantly lower TC (p=0.011) for approximately 40 hours after exercise.

**DISCUSSION**

To author’s knowledge, this was the first study to compare the immediate postexercise effects of acute bouts of golf, Nordic walking and walking on cardiometabolic markers in healthy older adults. Our findings indicate that these acute bouts of AE improve the cardiovascular profile of healthy older adults. Playing golf in particular seems to have a more positive effect on lipid profile and BG.

**Acute responses to exercise-specific outcomes**

In terms of HR and pace—which are intensity-related indicators—we observed predictable differences between golf, Nordic walking and walking. Previous studies have described Nordic walking as a more effective moderate-intensity exercise, whereas golf is considered
In agreement with our findings, the significantly longer duration of completing a round of golf compared with other exercise types may explain why golf is a more effective exercise than Nordic walking or walking based on energy expenditure, steps and distance. The energy expenditure of golf—as a long-term, lower-intensity exercise—can also induce positive responses to the metabolism. No significant difference between these exercise-specific outcomes was observed for Nordic walking versus walking. Studies have indicated that Nordic walking requires active use of upper body muscles, which should lead to a higher HR and greater energy consumption compared with walking.27 28 32 33 The lack of any difference in our findings could be due to the evaluation technique as only 25% of participants had tried Nordic walking before.26 34

### Acute responses to BG and blood lipids

In the between-group comparison, golf had a more positive effect on TGs and HDL-C than Nordic walking or walking. Golf also had a more positive effect on BG compared with walking. Interestingly, we found that golf seems to have a longer effect on TC compared with Nordic walking and walking. In addition, all the exercises reduced LDL-C and increased TGs. The exercise-specific mechanism of acute exercise on BG and lipids in healthy elderly people is not well known. Nonetheless, our study yielded similar results regarding the effectiveness of acute AE. Based on previous studies, the differences between golf, Nordic walking and walking can be explained by intensity, duration and energy expenditure even though acute effects of golf have not been studied before.3 28 33

Only a few studies with healthy adults have measured the differences in glucose concentrations between AE modalities. This is likely related to differences in carbohydrate metabolism due to the physiological differences of cycling and treadmill exercises in clinical conditions.3 33 This might be related to the total use of fatty acids (FAs) as an energy source. FA utilisation increases until the intensity of physical activity reaches approximately 60%–65% VO2max and 74% of the maximum HR, at which point an increase in the relative contribution of carbohydrate oxidation to energy expenditure occurs.10 This might clarify the previously reported view that the acute effect of exercise on glucose metabolism appears to require exercise near 70% VO2max.4 In our study, the intensity of golf was approximately 61%, while for Nordic walking and walking it was 76%–77% of the maximum HR. Golf affected BG more efficiently compared with walking due to a longer exercise duration, despite the lower intensity. This observation supports that a longer AE duration seems to provide a larger window for glucose concentration homoeostasis to be achieved.16 The absence of a difference in BG between golf and Nordic walking may be explained by Nordic walking requiring more muscle work, leading to a more positive impact on BG. Most studies have reported that a moderate-intensity exercise duration of around 45–60 min decreases glucose by an average approximate value of −0.83±1 mmol/L in healthy younger participants (31±21 years).3 35 However, in this study, BG was measured only once immediately (t=15 min) after the exercise session. Thus, there is a possibility that BG increases immediately after Nordic walking and walking but starts to decrease after a few hours as they are more intense activities than golf.

![Table 2](http://www.bmjopen.org/content/9/2/e001474)
Table 3 Acute responses to blood pressure, blood glucose and plasma lipid levels

<table>
<thead>
<tr>
<th>Cardiometabolic markers</th>
<th>Golf (n=24)</th>
<th>Nordic Walk (n=25)</th>
<th>Walk (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-exercise</td>
<td>Postexercise</td>
<td>Change</td>
</tr>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>142±17</td>
<td>134±13</td>
<td>−9±11</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>87±9</td>
<td>86±9</td>
<td>−1±7</td>
</tr>
<tr>
<td>Total cholesterol (mmol/L)</td>
<td>5.07±1.12</td>
<td>5.03±1.12</td>
<td>−0.05±0.2</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>1.01±0.31</td>
<td>1.14±0.38</td>
<td>0.13±0.2</td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/L)</td>
<td>2.92±0.87</td>
<td>2.85±0.98</td>
<td>−0.07±0.2</td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/L)</td>
<td>1.69±0.52</td>
<td>1.73±0.52</td>
<td>0.04±0.06</td>
</tr>
<tr>
<td>Blood glucose (mmol/l)</td>
<td>5.83±0.56</td>
<td>5.84±0.76</td>
<td>0.01±1.0</td>
</tr>
</tbody>
</table>

Quantitative variables were expressed as means±SD and in mean (95% CI). Bold values indicate a statistically significant difference with a p-value less than 0.05.

*To determine group differences pre-exercise and postexercise, the data were analysed using the Wilcoxon signed-rank test.
†To compare the differences in pre-exercise and change value between all groups, the data were analysed using the Kruskal-Wallis test.
‡Pairwise comparison was performed using the Kruskal-Wallis H test with post hoc adjustment using the Bonferroni correction: Golf versus Nordic walking.
§Pairwise comparison was performed using the Kruskal-Wallis H test with post hoc adjustment using the Bonferroni correction: Golf versus walking.
¶Pairwise comparison was performed using the Kruskal-Wallis H test with post hoc adjustment using the Bonferroni correction: Nordic walking versus walking.

HDL-cholesterol, high-density lipoprotein cholesterol; LDL-cholesterol, low-density lipoprotein cholesterol.
## Table 4  Wash-out period for pre-exercise of D1 and D3 to blood pressure, blood glucose and plasma lipid levels

<table>
<thead>
<tr>
<th>Cardiometabolic markers</th>
<th>Golf All (n=8)</th>
<th>Nordic walk All (n=9)</th>
<th>Walk All (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d1 (pre-exercise)</td>
<td>d3 (pre-exercise)</td>
<td>P value*</td>
</tr>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>140±13</td>
<td>139±13</td>
<td>0.779</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>88±8</td>
<td>77±8</td>
<td>0.075</td>
</tr>
<tr>
<td>Total cholesterol (mmol/L)</td>
<td>4.94±1.25</td>
<td>4.63±1.17</td>
<td>0.011</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>1.10±0.39</td>
<td>0.94±0.37</td>
<td>0.207</td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/L)</td>
<td>2.61±0.91</td>
<td>2.57±1.02</td>
<td>0.672</td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/L)</td>
<td>1.67±0.48</td>
<td>1.65±0.50</td>
<td>0.611</td>
</tr>
<tr>
<td>Blood glucose (mmol/L)</td>
<td>5.88±0.45</td>
<td>5.62±0.24</td>
<td>0.175</td>
</tr>
</tbody>
</table>

n (golf)=8, n (Nordic walking)=8, n (walking)=9.

Bold values indicates a statistically significant difference with a p-value less than 0.05.

*To determine group differences for day 1 (pre-exercise) and day 3 (pre-exercise), the data were analysed using the Wilcoxon signed-rank test.

d1, day1; d3, day3; HDL-cholesterol, high-density lipoprotein cholesterol; LDL-cholesterol, low-density lipoprotein cholesterol.
groups; this was expected as these are more intense AEs than golf. In a recent study, Ebine et al reported that the ground golf protocol reduced mean arterial BP in older adults (66±1.5 years). In our study, there was also a statistically significant reduction in sBP despite the lower intensity of golf. The results indicate that golf, Nordic walking and walking might have similar postexercise hypotension effects in healthy older adults. The lack of dBP in golf was expected as dBP does not change during acute low-intensity exercise. One past study found that walking does not reduce dBP, but another study also reported that dBP does not change during acute low-intensity exercise. While this study is focused on acute changes on cardiometabolic markers, it is important to consider the clinical significance of findings regarding the cardiometabolic markers measured. All type of AE, regardless of intensity or duration, appeared to produce favourable effects on BP in older adults. The same effect can be achieved by about 60 min of brisk walking or playing an 18-hole golf round. Aside from this finding, there were no moderate or large clinically significant changes in the other cardiometabolic markers.

**Study limitations**

Performing a study in a real-life environment according to typical standards allows for high generalisability, but not all factors can be controlled as in a laboratory setting. The small sample size and Fitbit Versa 3 data accuracy, especially on energy expenditure, should be considered carefully when evaluating the results. Due to the trial protocol, we recruited only golfers in the study as it was impossible to assign non-golfers to play a round of golf. Nordic walking was a new type of exercise for most participants, which may have led to poor technique and thereby decreased the effectiveness of the Nordic walking activity. Those who regularly play golf may have better overall health and be in better physical fitness, which limits the generalisability of the results to all older adults or to those with chronic conditions.

**CONCLUSION**

In conclusion, all three types of AE improved the cardiovascular profile in older adults when performed in acute bouts despite differences in duration and intensity. However, the lower exercise intensity of golf compared with Nordic walking and walking, the longer duration and higher total energy expenditure involved in playing golf seem to positively affect lipid profile and glucose metabolism. These age-appropriate AEs can be recommended to healthy older adults as a form of health-enhancing physical activity to prevent CVDs and can also be used as a treatment strategy to improve cardiometabolic health among those who already have a CVD.

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