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HEART RATE, MOOD STATES, AND RATING OF PERCEIVED EXERTION AMONG ELDERLY SUBJECTS DURING 3.5 HOURS OF RECREATIONAL ALPINE SKIING

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ABSTRACT

A decline in physiological functioning and mental wellbeing is common with advancing age. However, these changes may vary among elderly individuals. Physical activity and the response of the elderly to exercise during recreational activities, i.e., recreational alpine skiing, may serve as a catalyst for the improvement of wellbeing and general health. ***Purpose:*** *The aim of the study was to assess the heart rate (HR) response modulations in a group of elderly recreational alpine skiers during 3.5h of skiing. In addition, each group's perceived responses of mood state (MS) and rating of perceived exertion (RPE) were collected to determine possible contributions to changes in wellbeing as a result of recreational skiing.* ***Methods:*** *Forty-nine healthy elderly participants (mean age: 63±6 yrs, weight: 75.4+13.1 kg, height: 170.5+9.1 cm, BMI: 26+3.2) with at least basic alpine skiing ability participated in a 3.5h ski test. GPS data (GPS Garmin Forerunner 301) were used to monitor altitude and HR and were recorded continuously during the 3.5h of skiing. During skiing, participants were asked at three different times to report RPE and MS.* ***Results:*** *The time spent on the lift during the 3.5h skiing ranged from 21-58% followed by recovery breaks of 17-53% and time spent in downhill skiing ranged from 12-40%. Participants completed 9-23 downhill runs in 3.5h. Average intensities during 3.5 h downhill runs for over 80% of the*

group were between 50-80% of maximal heart rate (HRmax) (220-age). Peak heart rate (HRpeak) values during downhill runs for 35% of the group were between 60-70% of HRmax. Statistical analysis revealed numerous significant differences between RPE and MS values for the three different sampling times. The MS in general remained positive and even increased in the categories of happiness and sociability despite an increase in fatigue. ***Conclusion:*** *The results of this study suggest that the duration and intensity of skiing was appropriate and yielded immediate positive psychological effects on the elderly subjects. Furthermore, recreational alpine skiing has a positive effect on MS ratings reflecting wellbeing, while generating age-appropriate moderate RPE values in elderly alpine skiers.*

Keywords: *aging, wellbeing, alpine skiing, mood states*

SRČNI UTRIP, RAZPOLOŽENJE IN NAPOR STAREJŠIH OSEB MED 3,5-URNIM REKREATIVNIM ALPSKIM SMUČANJEM

IZVLEČEK

Zmanjšana telesna aktivnost in slabše duševno počutje sta v starosti pogosta pojava, vendar pa se med starejšimi te spremembe precej razlikujejo. Telesna aktivnost in pripravljenost na izvajanje rekreativnih dejavnosti, kot je na primer rekreacijsko alpsko smučanje, lahko starejšim ljudem pomaga izboljšati počutje in splošno zdravje. ***Namen:*** *Cilj študije je bil oceniti odzivne modulacije srčnega utripa (SU) v skupini starejših rekreacijskih alpskih smučarjev med 3,5 urami smučanja. Poleg tega smo zbirali podatke o zaznanih spremembah v razpoloženju (R) in o lastni oceni zaznanega napora (OZN) pri vsaki skupini, da bi določili, kakšen doprinos k izboljšanju počutja ima lahko telesna vadba.* ***Metode:*** *Devetinštirideset zdravih starejših udeležencev (povprečna starost: 63 ± 6 let, teža: 75,4 ± 13,1 kg, višina: 170,5 ± 9,1 cm ITM: 26 ± 3,2) z vsaj osnovnim znanjem rekreativnega smučanja je sodelovalo v 3,5-urnem smučarskem preizkusu. Za spremljanje sprememb srčnega utripa glede na nadmorsko višino smo zapisovali podatke GPS (GPS Garmin Forerunner 301), ki so se v času 3,5-urnega smučanja neprestano shranjevali. Udeležence smo med smučanjem na treh različnih točkah prosili, da poročajo o svoji OZN in R.* ***Rezultati:*** *Čas, porabljen za vzpone med 3,5 urami smučanja, je nihal med 21–58 %, sledili so odmori za počitek v razponu 17–53 %, najmanj pa je bilo časa, preživetega v dejanskem smučanju, ki je znašal 12–40 % vsega preživetega časa aktivnosti. Udeleženci so opravili 9 do 23 spustov v 3,5 urah. Povprečne intenzivnosti med 3,5-urnim spustom so pri več kot 80 % udeležencev znašale med 50–80 % maksimalnega srčnega utripa (SUmax) (220-starost). Najvišje vrednosti srčnega utripa (SUvrh) med spustom za 35 % udeležencev pa so znašale med 60–70 % SUmax. Statistična analiza je pokazala številne znatne*

razlike med vrednostmi OZN in R v treh različnih časih vzorčenja. R je na splošno ostal pozitiven in se je kljub povečani utrujenosti celo povečal v kategorijah veselja in družabnosti. ***Zaključek:*** *Rezultati raziskave kažejo, da sta bila trajanje in intenzivnost smučanja primerna in sta imela na starejše osebe takojšnje pozitivne psihološke učinke. Poleg tega je bilo dokazano, da ima rekreativno alpsko smučanje pozitiven vpliv na ocene R, ki se odražajo v dobrem počutju, hkrati pa ustvarjajo starosti primerne zmerne spremembe vrednosti OZN pri starejših rekreativnih smučarjih.*

Ključne besede: *staranje, dobro počutje, alpsko smučanje, razpoloženje*

INTRODUCTION

The decrease in physical functioning associated with advancing age is often accompanied by a reduction in psychological abilities. However, the degree of age related functioning is not determined by the aging process alone; it often depends on individual lifestyle as well (Hollmann & Hettinger, 2000). A physically active lifestyle contributes to better physical functioning and mental health. The physically active elderly can often compensate for diminished functioning by energizing their innate assets more effectively when compared to sedentary individuals, as reported by Olbrich (1987, 1992; Kirchner & Schaller, 1996; Israel, 1995). Therefore, a suitable exercise regimen is generally based on the intensity, duration, and frequency of exercise recommended for individuals within a specific age range (American College of Sports Medicine, 1998).

The American College of Sports Medicine (1998) recommends training intensities between 60 - 90% of maximal HR (HRmax) for 30 - 60 min 3 - 5 times per week to improve cardiovascular health. Pahlke (1995) reported that aerobic exercise is an important factor in maintaining and improving the cardiovascular system and sustaining overall health and wellness during the aging process.

In addition to the physiological components, psychological wellbeing, positive MS, and motivation are equally important and contribute to improved overall health in the elderly (Samitz & Mensink, 2002).

Alpine skiing as an athletic and recreational activity is a small part of global sports. However, in snowy mountainous regions it is an integral part of the lifestyle of both young and old. Recreational alpine skiing thus potentially offers significant physical and psychological improvements for the elderly.

Although alpine skiing in the mountainous regions has a long tradition, it has not often been viewed a beneficial sport for seniors. Prokop and Bachl (1984) describe alpine skiing as risky due to high physical strain and psychological stress. However, in the last few years, the focus has been shifting to recreational skiing and the resulting psychobiological benefits for skiers, especially the elderly. Kahn and Jouanin (1996) as well as Vater et al. (2005) support alpine skiing's preventative function and its promotion of general wellbeing among the elderly. However, the majority of studies assessing rec-

reational skiing have used more rigid test designs utilizing prescribed skiing patterns, allowing little latitude for individuality as it would normally occur during free skiing.

Therefore, the purpose of this study was to monitor HR responses that partially reflect physiological demands and to collect subjective ratings of effort and individual mood state via a questionnaire in a representative group of elderly recreational skiers as they skied in their habitual skiing patterns.

METHODS

Participants

Forty-nine apparently healthy volunteer elderly individuals participated in our study. Participants were > 50 years of age with at least basic alpine skiing abilities and were were recruited via personal contact and word of mouth. The participant group consisted of 16 women [mean age: 60.4±4.4 yrs, weight (Wt): 65.7+10.2 kg, height (Ht): 162.5+5.8 cm, body mass index (BMI): 26.3+2.6] and 33 men [mean age: 64.5±6 yrs, Wt: 78.9+12.3 kg, Ht: 173.4+8.3 cm, BMI: 25.9+3.5] with a combined mean age of 63.4+63, Wt: 75.4+13.1 kg, Ht: 170.5+9.1 cm, BMI: 26.0+3.2. Currently, there are no data available in the literature similar to or representative of our study with respect to elderly recreational skiers.

The skiing ability of our elderly subjects ranged from basic to expert. Participants were classified according to the Austrian Ski Teaching Concept (Wörndle, 2007) as determined by a certified Austrian ski instructor.

Participants were given a questionnaire in which they were asked to describe their general exercise behavior. The questionnaire revealed that 62% of the women and 57% of men were involved in more than 5 h of sports per week. Forty-nine percent of the group described the exercise effort as easy and 51% as demanding during their typical 5 h of exercise. Regarding exertion level, 37 participants reported some degree of physical discomfort in general. Of those 37, 25 complained of knee problems and 19 of lower back problems.

Thirty participants skied > 28 days per year. Two participants skied 22-28, 4 had 15-21, 10 had 8-14, and three skied less than eight days per year. A common skiing day varied among participants from 2-8 hours.

The physical working capacity test up to a HR of 130 beats per min (bpm) (PWC130) was conducted on an electronically braked cycle ergometer (Kettler CX1, Kettler, Salzburg, Austria) a week after the skiing session to determine the physical fitness of the participants. The combined group averaged 1.7 ± 0.3 W.kg-1measured during the PWC130 test. Women averaged 1.5 ± 0.3 W.kg-1 and men 1.7± 0.3 W.kg-1.

Sixteen participants were taking prescribed hypertension medication that may have influenced HR response during testing; however, there were no significant differences

in HR responses during skiing between medicated and non-medicated participants. We therefore elected to treat medicated and non-medicated subjects as a single group.

Study design

This study was approved by the local ethics committee and written informed consent was obtained from all participants prior to testing. Subjects participated in a total of 3.5 h of skiing field testing on the slopes of Hinterreit in Salzburg, at an altitude of 780-1180 m. The ski area has three different slopes serviced by two T-bar lifts. Vertical altitude difference for the lower lift was 246 m and required on average a 6-min T-bar lift to reach the top of the lift. The vertical altitude difference for the upper ski lift was 288 m and required a ride of ~5-min. The selected ski area consisted of a variety of open ski slopes. Ski steepness ranged from <25% to a nearly 40% grade. Participants were free to select their preferred slopes.

The weather conditions were sunny to light cloudiness without condensation. Temperature throughout the testing days was consistently between -6 to -2 °C in the mornings to +4 to +8 °C in the afternoons.

The field-test protocol was explained in detail to all participants until all aspects of the testing were understood. The participants were subsequently fitted with a HR chest strap and global positioning system (GPS) monitoring equipment (GARMIN Forerunner 301, Garmin©, USA) on the upper arm. Data were recorded continuously during skiing in all participants. Participants started skiing at 10:15 AM. They were asked to ski as they normally would and at a speed comfortable for them, and to feel free to rest on the slopes when desired.

The duration and frequency of skiing were measured by analyzing the time of actual downhill runs and recovery breaks. These two combined constituted a single cycle. Downhill run time was defined by changes in altitude. The recovery phase was defined as the time between two downhill runs, consisting of T-bar lift use and break time before and after T-bar lift use (Figure 1). An example of HR response for a single subject during three downhill runs and T-bar use/recovery as a function of altitude is also shown in Figure 1. To describe cycle characteristics, a relationship between length of recovery and downhill skiing run time was calculated. Thus, recovery time was divided by the time of the downhill runs.

Physical exertion during downhill runs and recovery time were assessed via HR response throughout the skiing periods and during T-bar lift use. The mean HR (HRmean), as well as peak HR (HRpeak) and minimal HR (HRmin) during downhill runs and during T-bar lift use were used to estimate the intensity of exertion among the elderly skiers during skiing. T-bar lift use and downhill runs were determined by differences in altitude as recorded by the GPS.

The mean HR was determined using the average HR for all downhill runs for each individual. Peak HR represents the highest HR achieved during each downhill run and averaged for all downhill runs. Similarly, the minimal HR represents the lowest HR measured during T-bar lift use.

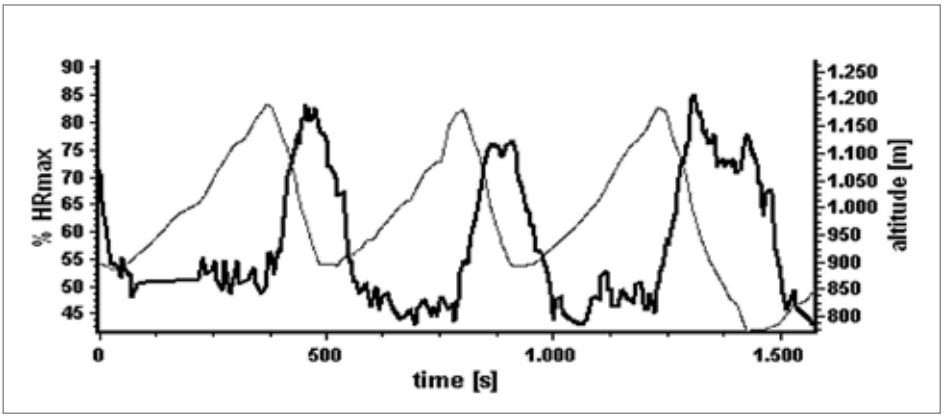

Figure1: Example of heart rate (HR) response for a single subject during 3 consecutive downhill-runs and T-bar use/recovery phase as a function of altitude.

In our study we express HR as percentage of maximal HR using the following formula HRmax = 220-age, knowing that there may be differences between estimated HRmax and actual achieved maximal HR. However, due to the age of the participants and for logistical reasons, the age related formula was used to represent HRmax values, in accordance with Karvonen and Vuorimaa (1988).

To determine the individual mind-set that would reflect the physical sensations of skiing, each participant was asked to answer questions regarding their perception of MS using the Hackfort and Schlattmann (1995) questionnaire consisting of a 10-point scale from 0 = none to 10 = in complete agreement, and including the following nine dimensions: readiness for the activity, sociability, self-confidence, happiness, nervousness, fatigue or exhaustion, anger, worry, and concentration (Hackfort & Schlattmann, 1995). A positive MS was expressed along the following five dimensions: readiness for the activity, sociability, self-confidence, happiness, and concentration, while the negative MS dimensions were expressed in terms of: nervousness, fatigue and exhaustion, anger, and worry.

Exertion ratings were estimated using Borg's 15-point scale (6 = no effort to 20 = complete exhaustion; Borg, 1985). The MS questionnaire and RPE for each individual were determined at 0.5 h (T1), between 1.5 - 2 h (T2) and at the end of 3.5 h of skiing (T3). Data for HR and GPS were analyzed using "Training Center 2.3", Sports Tracks (Garmin©, Olathe, Kansas, USA) and Ikemaster (Ike Software Solutions, Salzburg, Austria) software, and were analyzed statistically with SPSS v. 15.0 statistical software (SPSS, Chicago, IL, USA).

One-way repeated measures analysis of variance, Mann-Whitney U-Tests, and Wilcoxon Sign-Tests were used to evaluate RPE values, the questionnaire scale for MS, ans HR and GPS data. Significance was set at an alpha level of $p \leq 0.05$.

RESULTS

The skiing group covered a mean vertical distance of 4,370 ± 956 m during testing. The range of vertical distance values covered by the group was between 1,971 and 6,211 m.

Time spent on the T-bar lift was 43±8% (range 21%-58%), downhill ski runs 19±5% (range 12-40%) and break time was 38±9% (range 17-53%) for the 3.5 h ski testing day.

The recovery to downhill runs ratio ranged from 4:1 (6 min recovery to 1.5 min downhill runs = 4:1) to 1:1 (10 min recovery to 10 min downhill runs = 1:1). Participants completed between 9-23 downhill runs in the allotted time.

Mean heart rate (HRmean) within the group during downhill runs was 70±10% of maximal HR (HRmax). Mean HR (HRmean) for the group during lift runs was 60±10% of HRmax. Mean peak HR (HRpeak) for downhill runs was 76±12%. Mean minimal HR (HRmin) recorded for T-bar lift runs was 54±9% of HRmax. HR responses during skiing for the male, female, and combined groups are depicted in Table 1.

Table 1: Heart rate (HR) response (peak and mean) for combined group (CG), male and female group for the 3.5 h skiing session. Values are mean + SD; (N = 49).

Variable	Combined Group Mean + SD (N=49)	Males Mean + SD (N=33)	Females Mean + SD (N=16)
HRpeak (bpm)	119.7 + 18.4	123.9 + 19.9	111.0 + 11.0
HRmean (bpm) (overall)	106.8 + 22.5	109.0 + 26.4	102.3 + 10.1
HRmin (bpm) (lift/recovery)	93.2 + 15.0	93.8 + 23.6	85.8 + 8.3

bpm = beats per minute; HRpeak = peak heart rate; HRmean = mean heart rate; HRmin = minimum heart rate

Forty percent of the group had HRmean values during downhill runs between 60-70% of HRmax; 26% had HRmean between 70-80%; 15% were between 50-60 % and 2% of the group had HR below 50% or in some cases above 90% of HRmax. Fourteen perecent had HRmean of 70-80%, 24% had HRmean of 60-70%; 44% had HRmean of 50-60%, and 14% had HRmean below 50% of HRmax during T-bar lift use (Figure 2).

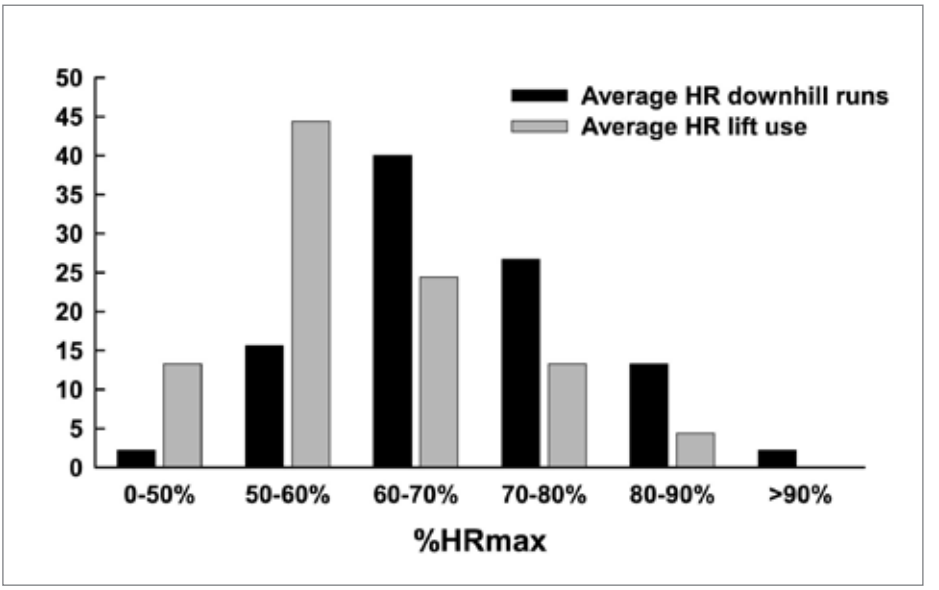

Figure 2: Mean heart rate (HR) response during downhill runs and T-bar use during the 3.5 h recreational skiing session for the combined group (N = 49).

Thirty-five percent of the group had a peak HR that corresponded to 60-70% of maximal HR. Twenty-four percent had a peak HR that was 80-90% of HRmax and 22% had HRpeak values of 70-80% HRmax. Fifteen percent of the group had HRpeak above 90% of HRmax and 4% reached 50-60% of HRmax (Figure 2).

Positive MS scores ranged from 7.7±0.1 to 9.0±0.3 for all time points for the combined group. Negative MS ranged from 0.2±0.5 and 1.1±0.5. Statistically significant differences were found for positive and negative MS scores over time between T1, T2 and T3 and for negative MS over the entire skiing session (Figure 3).

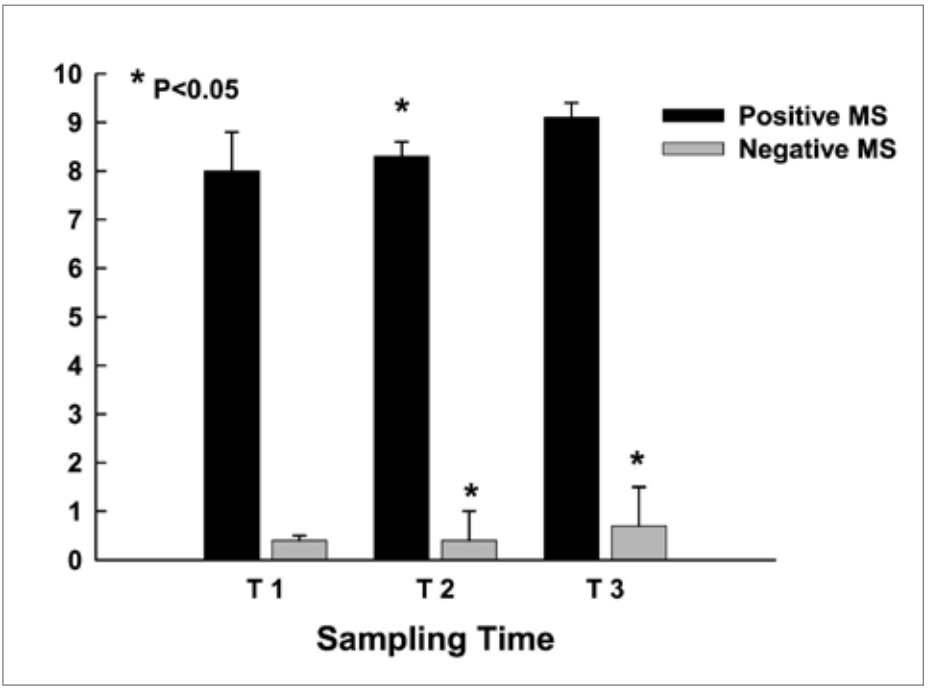

Figure 3: Mood states (MS) score recorded at 3 designated time points during 3.5 h of recreational skiing for all participants (N = 49). Values are mean + SD.

Significant changes were also found for certain dimensions of MS and between recorded time periods. Fatigue increased between T1 and T3 (p=0.001), between T2 and T3 (p=0.001) and over the entire skiing session (p=0.001). Sociability increased between T1 and T2 (p=0.01) and between T1 and T3 (p=0.017) and for the entire session (p=0.005). Happiness yielded an increase between T1 and T2 (p=0.04) and over the entire skiing session (p=0.03). Dimensions describing activity, concentration, self-confidence, nervousness, anger and depression were not significantly different during the 3.5 h of skiing (Figure 3).

Ratings of perceived exertion for the entire group revealed significant increases between T1-T2 (p=0.04), T1-T3 (p=0.001) and the entire session (p=0.001) (Figure 4).

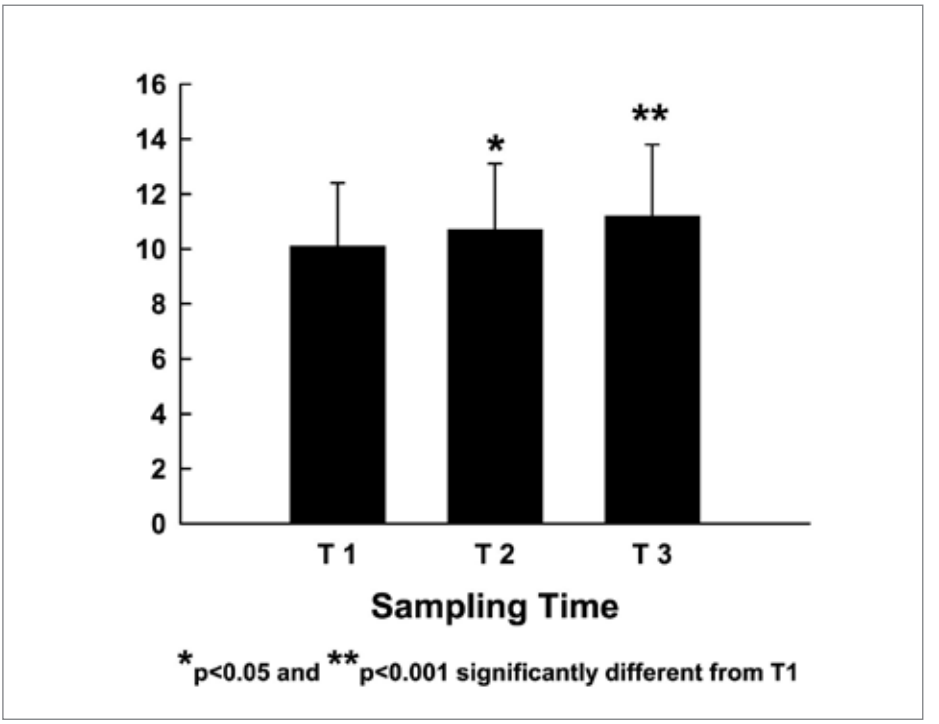

Figure 4: Ratings of perceived exertion (RPE, Borg Scale 6-20) recorded during 3 designated sampling times of 3.5 hours of recreational skiing for the combined group of participants (N = 49). Values are mean + SD.

DISCUSSION AND CONCLUSIONS

When assessing the variables that describe the intensity, HR responses, and physical demands of recreational skiing in the elderly, the results of our study lend support to the guidelines recommended by the American College of Sports Medicine (ACSM, 1998; Hollmann & Hettinger, 2000) as well as Prokop and Bachl (1984). Sixty-five percent of our elderly participants skied within the health-promoting domain of 60-80% of maximal HR (ACSM, 1998). For a few participants within our group, the intensity during T-bar lift use was above the level of minimal demand and may have minimally influenced the cardiovascular system. Participants who exhibited a higher physical exertion on downhill-runs observed during high relative HR values may have been psychologically more willing to accept higher intensities and physical demands compared to others in the group.

Heart rate alone does not reflect all of the metabolic or physiological responses and, as reported by Seifert et al. (2008), should not be viewed as the sole factor indicative of physical fatigue. In our study, the measured HR does, however, provide a broader indication of the level of physical exertion experienced by the elderly during skiing. Our participants were free to ski using their preferred skiing styles and patterns. They were not under any specific mental pressure or psychological stress, as was reflected in their higher ratings of positive mood states. We therefore postulate that psychologically based influence did not affect HR response during skiing and was not a major factor that would alter the results of our study.

The average HR values combined with cycle characteristics (recovery to downhill run ratio) in our study clearly show that alpine skiing is not a steady-state continuous activity like walking, jogging, running, or cycling. It is a mixture of high and low intensity activity and could be characterized as an intermittent activity (Zintl, 2001). The continuous type of steady-state, moderate-intensity activity is generally prescribed to increase aerobic capacity and is therefore more commonly adhered to when participating in an activity or as recommended exercise for the elderly.

During alpine skiing, the duration of stimuli is based on individual preferences and the characteristics of ski slopes, especially length and steepness. Therefore, the characteristics of the intensity and recovery cycle often depend on slope characteristics. The ski slopes in our ski testing area were comparatively short. This affected not only cycle characteristics but also the number and duration of breaks during downhill runs.

The variables describing differences in altitude are also affected by the characteristics of the testing area and its setting. Variables that were measured included the steepness and length of the slopes as well as T-bar lift speed. The skiing pattern of each individual skier was determined by measuring frequency of breaks, preferred skiing speed, radii and length of turns modulate the variables describing differences in altitude to varying degrees. Large differences in vertical distance skied may be due to variations in skiing proficiency level, whereas smaller differences may be accounted for by other reasons and cannot be explained by a single factor. Therefore, the vertical distance covered during skiing, expressed in meters, could only be compared for a single subject. Each subject's skiing may be influenced by the characteristics of the skiing area and skiing conditions.

During skiing sessions, the person with the shortest downhill run time did not ski for less than 25 min of absolute skiing time in the 3.5 h session. The longest absolute time spent on downhill runs was 84 min. Due to the large variability in skiing time among our participants, physical exertion time (absolute skiing time) was variable. Participants who utilized the shortest absolute skiing time were near or below the threshold for physical activity that may serve to improve fitness, as suggested by ACSM (1998). Heart rate values during skiing did not correlate with break time, skiing time or lift time within the group. We postulate that this was due to the lack of standardizing of skiing technique, style, and speed. Participants were allowed to vary the length and number of breaks and to elicit their individual preferred intensity, resulting in mostly moderate exertion levels. These were subsequently reflected in moderate RPE scores.

Although, there was a significant increase in the sense of exertion reported, RPE rating remained in the lower third on the Borg scale even at the end of the skiing session. Hence, a moderate feeling of physical exertion associated with skiing intensity was not indicative of fatigue or exhaustion. This finding is consistent with the below-threshold intensity that contributes to benefits from sports activities recommended for the elderly (Hollmann & Hettinger, 2001; ACSM, 1998; Prokop & Bachl, 1984).

The high scores recorded for the positive MS categories at the first measurement (T1) may be viewed as anticipatory since participants knew that they had another 3 h of skiing available to them. As a few participants were unfamiliar with the setting, we interpret these findings as an indication that participants were becoming comfortable with the test setting and conditions after the initial 30 min of skiing. Therefore, recreational skiing appears to increase individual drive and motivation for the physical activity that is an important factor in sports and physical activity in the elderly, as reported by Dahlhaus (2004).

The first administration of the questionnaire (30 min) revealed positive responses for MS and numerous categories of positive MS increased with the additional 3 h of skiing. High positive MS scores were recorded for the dimensions of happiness and sociability during the ski session, even though there was an increase in the feeling of fatigue. Our results agree with Samitz and Mensink (2002), who suggest that recreational alpine skiing represents a positive and inspiring MS activity for the elderly.

As described by Grosser et al. (2001), the physical demands of sport and exercise are influenced by internal and external factors. In alpine skiing, internal factors include individual skill level, style and technique, in addition to physiological capacity and motivational factors. External factors include the characteristics of ski slopes such as steepness and length, ski lifts, weather, snow conditions, crowded skiing conditions, and use of skiing equipment, to name a few as described by Vater et al. (2005). External factors may be influenced by pre-screening and other sources of information detailing the infrastructure of the skiing area and resorts, and possibly also by the choice of skiing equipment.

It is difficult to discern a direct relationship of HR to various internal and external factors due to the complexity of activity, and therefore we did not expect to find a direct relationship or cause and effect of each variable that may be responsible for the overall perception of the stress and demands of skiing. In a different study with a similar age group of participants, the authors found no direct relationship between physical fitness and HR response during recreational skiing (Krautgasser et al., 2009). Similar results were reported by Scheiber et al. (2009). They found only low correlations between PWC130 and exertion level in a group of elderly skiers of equal skill level. The authors concluded that the participants controlled skiing intensity to avoid fatigue. Their results support our assumption that, based on an amenable selection of skiing terrain and slopes, better skilled skiers vary their skiing intensity, unlike less skilled skiers, who appear to resort to reduced speed in order to better control skiing intensity, and who take longer break times to avoid fatigue. Although we did not find a direct correlation between physical exertion and mood states during free recreational skiing, physical

fitness is highly desirable and offers the possibility of beneficial exercise response, especially for individuals with a predisposition for cardiovascular diseases as reported by Burtscher et al. (2005) and Burtscher (2007).

In accordance with the findings of Faulhaber et al. (2007a) and Faulhaber et al. (2007b), our results suggest that elderly skiers should take into account any existing health problems, avoid unnecessary risk of injury, and recognize their physical limitations in order to maximally benefit from exercise and physical activity. The results of our study support the findings of other investigations indicating that alpine skiing positively affects physical and psychological wellbeing as well as mood state among elderly recreational skiers.

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