

Health Benefits of Non-Motorized Outdoor Recreation: A Summary of Published Findings



Stephen Kux
Wolfgang Haider

School of Resource and Environmental Management
Simon Fraser University
Burnaby, British Columbia
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Executive Summary

The purpose of this review is to summarize existing research into the health benefits associated with non-motorized outdoor recreation activities. So far academic research has paid scant attention to this topic, but over the past decade a number of interesting and innovative projects have been undertaken in several countries by health sciences and some social sciences, resulting in actual measurements of health effects. As physical inactivity and obesity are increasing in developed nations, understanding how public health can be improved through engagement in activities that people enjoy is gaining importance. In particular, this review is focused on the following research questions:

- 1) What specific outdoor recreation activities have been correlated with improved physical health?
- 2) What specific benefits to physical health have been observed in correlation with participation in non-motorized outdoor recreation activities?
- 3) Which health benefits are linked to which activities?
- 4) What benefits to health are associated with time spent in natural environments versus urban environments?

The existing literature presents a range of activities that have been linked with benefits to physical health, however three activities stand out with respect to experimental findings: Hiking, rock climbing, and alpine skiing. These activities may not necessarily be the activities with the largest health benefits, but so far they happen to have received the most attention. Hiking has been studied most extensively compared with other outdoor recreation activities and has been linked to health benefits such as:

- A 50% reduction in the risk of coronary artery disease (Hakim et al., 1999).
- Improved heart function, to a degree that is comparable to a moderate intensity workout on a stationary bike (Huonker et al., 1997).
- Improved insulin sensitivity (Lee et al., 2004; Schobersberger et al., 2010).
- An accumulation of lean body mass (Lee et al., 2004).
- Reduced heart rate and blood pressure (Schobersberger et al., 2010).
- Increases in the number of naturally generated stem cells in the blood of adults (Schobersberger et al., 2010).
- Reductions in blood-bound “bad cholesterol” (low-density lipoproteins) (Faber et al., 1992).
- Improvements in the perceived health of participants (Strauss-Blanche et al., 2004).

Rock climbing is another activity that demonstrates a range of benefits to health, including:

- Improved cardiovascular fitness and muscular endurance (Draper et al., 2010; Mermier et al., 1997; Rodio et al., 2008).
- Improved aerobic function based on the standards presented by the American College of Sports Medicine (Rodio et al., 2008).
- Metabolic responses related to how efficiently the body makes use of oxygen, which have not been seen in other sports (Draper et al., 2010).
- Improved hormone regulation (Sherk et al., 2010).
- Improved physical strength and body composition in children (Balas et al., 2009).

Alpine skiing has also been linked to a number of benefits to physical health, such as:

- Enhanced hormone production (Kahn et al., 1996).
- Lasting improvements to both resting heart rate and blood pressure (Kahn et al., 1996; Niederseer et al., 2011).
- Reduced risk of cardiovascular disease in both middle aged and elderly participants (Kahn et al., 1996; Niederseer et al., 2011).
- Improvements to how efficiently the body absorbs oxygen (Mueller et al., 2011).
- Improved jump height, dynamic leg strength, and balance in the elderly (Mueller et al., 2011).

Plenty of evidence suggests that simply being present in a natural setting accrues health benefits not seen in participants who spend their time in an urban environment. These benefits pertain to both mental and physical health and include:

- Heightened cognitive function (demonstrated through a proof-reading task) (Hartig et al., 1991)
- Higher reported happiness (Hartig et al., 1991).
- Perceived rejuvenation (Hartig et al., 1991).
- Improved attention span (Cimprich, 1992).
- Greater motivation to address challenges in one's life (Cimprich, 1992).
- Stabilized heart rate (Lee et al., 2011; Li et al., 2008a)
- Reduced production of stress hormones (Lee et al., 2011).
- Enhanced responsiveness to stimuli (Lee et al., 2011).
- Heightened immune system function and increased production of anti-cancer proteins (Li et al., 2008a; Li et al., 2008b).
- Increases in reported spiritual inspiration (Fredrickson & Anderson, 1999).

There are caveats that go along with these findings. The health benefits presented are often acute, making an understanding of the long-term effects of participation in outdoor recreation difficult to ascertain. Furthermore, there are important research questions that have yet to be answered such as: What length of exposure is required for effects to take hold? What is the relationship between the time spent engaging in an activity and the persistence of the benefits derived from it? How much of the measured effect is a product of the activity being studied and how much of it is a product of simply being on vacation? Is there a social component to the observed benefits?

That being said, there is strong evidence in favour of outdoor recreation as a means of improving physical health. Given the potential for outdoor recreation activities to attract participants and foster life-long hobbies, there is reason to be optimistic with regards to promoting physical fitness through these activities.

Health Benefits of Non-Motorized Outdoor Recreation

Participation in non-motorized outdoor recreation significantly benefits the mental and physical health of the population in which it is undertaken. Many studies outline both the general and activity-specific contributions to health that are provided by participation in these activities and this review will serve to synthesize and make connections between them.

In a time when inactivity has become a major public health concern, it is important to understand all the ways in which physical activity can remedy the maladies caused by the emphasis on convenience that is presently prevalent in western culture. A recent study by Janssen (2012) sought to estimate the Canadian health care costs accompanying physical inactivity and its related diseases. Janssen employed a prevalence-based approach using three elements to better understand the cost of inactivity. The risk of developing seven chronic diseases associated with physical inactivity was compared with the annual direct and indirect health care costs of those diseases and the prevalence of physical inactivity in the Canadian population. The seven diseases used in this analysis were not exhaustive, but generally agreed upon potential consequences of an inactive lifestyle and included: coronary artery disease, stroke, hypertension, colon cancer, breast cancer, Type 2 diabetes, and osteoporosis. The rate of occurrence of physical inactivity was taken from the 2009 Canadian Health Measures Study commissioned by the federal government and was set at 82.9% for men and 86.3% for women. Using these figures, the estimated direct health care costs incurred as a result of physical inactivity were \$2.4 billion per year. Compounded with an estimated \$4.3 billion dollars in indirect costs (such as lost workforce productivity) the total cost of physical inactivity in Canada is set at \$6.8 billion annually (Janssen, 2012).

These figures raise concern for both the health of the Canadian population as well as the economy, and require politicians and community coordinators to seek out accessible physical activities that might help ameliorate the deleterious effects of inactivity. Fortunately, Canadian culture and geography combine to provide a range of cost-effective solutions to this national problem. Canadian culture has long been tied to the union between people and the outdoors to the benefit of both. It is this reputation and these opportunities that provide the simplest and most effective potential solutions to the concern of inactivity. Activities like hiking, skiing, rock climbing, and mountaineering have been the subject of much scientific inquiry aimed at evaluating the impact of such activities on personal health. Each of these activities offers health benefits that are associated with any form of exercise (ex. improved cardiovascular fitness and weight loss) but there are also unique benefits that go along with each form of recreation, making it important to look at different forms separately. The following sections summarize the general findings of academic research as it relates to specific non-motorized outdoor recreational pursuits.

Hiking

Hiking is arguably the most accessible and least intense way for the average person to undertake outdoor recreation; however, it has been found to have some of the most significant physiological effects. At its roots, hiking is simply the act of walking in a natural setting. Obviously, the lack of specificity inherent in this definition provides broad interpretations of the

effectiveness of hiking as exercise. However, even at a leisurely pace on non-technical terrain, hiking has been found to provide far reaching benefits. A foundational work on the health benefits of an active lifestyle was conducted by Hakim et al. in 1999 and provides evidence that regular walking is beneficial to cardiac health. Researchers examined the risk of coronary artery disease (CAD) in elderly men who walked various distances. Distance walked was evaluated in 2,678 men aged 71 to 93 at baseline examinations between 1991 and 1993 as part of the Honolulu Heart Program. Instances of CAD were observed over a 2 to 4 year follow-up. Results suggest that men who walked less than 0.25 miles (0.4 km) per day exhibit twice the risk of developing CAD compared with men who walked more than 1.5 miles (2.4 km) per day; and both of these groups were significantly more likely to develop CAD than men who walked even further (Hakim et al., 1999).

Taking the work of Hakim et al. (1999) as starting point, it is easy to understand how the health benefits of light daily walking may translate into similar effects for people engaged in mountain hiking at moderate altitudes. A 1997 study by Huonker et al. looked at the impacts of highland mountain hiking on the health of men with existing CAD in an attempt to understand their tolerance for exercise and the effect hiking might have on heart function. In order to make specific claims about hiking compared to more conventional means of cardiovascular exercise, researchers compared results of a mountain hiking session (8.7 km at between 470 m and 1,220 m elevation) with corresponding data from a multistage upright cycling session (Huonker et al., 1997). Eleven men with stable CAD were compared with 9 healthy control participants on measures of intensity during exercise. The men with CAD showed significantly improved heart function while hiking. The workload elicited from hiking was equivalent with cycling at a rate of 100 to 120 Watts on the upright cycle. Huonker et al. (1997) conclude that hiking is a comparable alternative to more conventional means of cardiovascular exercise and suggest that it is an effective means of improving heart function for both healthy individuals and those with pre-existing heart conditions (Huonker et al., 1997).

The notion that hiking is an effective way to improve the health of individuals with pre-existing conditions has been further supported by the work of Lee et al. (2004). Researchers examined the physical health impacts of long-range hiking on a group of recovering drug addicts. Prior to their participation in the study, participants had demonstrated 13 – 100% increases in body weight and a trend toward insulin resistance as a result of their recovery from drug addiction. Nine men participated in the hiking therapy which consisted of 25 days spent hiking at altitudes between 2,200 and 3,800 meters. On day 25, the men were compared to 17 healthy controls on a number of measures of physical health. Insulin sensitivity was found to have normalized over the course of the expedition, and the men showed marked improvements in both Waist-to-Hip ratio and lean body mass (Lee et al., 2004). The authors conclude that participating in physical activity at altitude has a restorative effect on insulin sensitivity and speculate that this effect is due, at least in part, to a reduction in central fatness (Lee et al., 2004). This study provides evidence for how non-motorized outdoor recreation, particularly at altitude, can be used to restore damaged health to normal levels in a relatively short period of time.

Hiking at altitude, however, is not only beneficial for improving damaged bodies. Exposure to hiking at moderate altitudes has also been found to lead to improved health in average people. In research done as part of the 2010 Austrian Moderate Altitude study,

researchers Schobersberger, Leichtfried, Mueck-Weymann, and Humpeler examined the impact of active vacations at moderate altitude on the health of normal participants. The main body of research occurred following a pilot study which suggested that 3-week vacations at altitude offer numerous benefits to health. The main effects observed through this pilot study were reduced heart rate, blood pressure, and insulin resistance (Schobersberger et al., 2010). For the main study, 71 participants took part in 3-week simulated vacations at either low or moderate altitude. The vacations included 3-4 hour guided hikes, relaxation and rejuvenation in hotel spas, and no dietary restrictions. Both groups showed a significant reduction in blood pressure, body weight, body fat, reduced total cholesterol, and improved perceived health (Schobersberger et al., 2010).

Part 2 of this study involved 16 healthy participants who spent one week at a four star hotel at 1700 m elevation. The vacation included 5 guided hiking tours of moderate intensity. The participants in Part 2 of the study also had no dietary restrictions (Schobersberger et al., 2010). Participants demonstrated an increase in the number of stem cells circulating in their blood. These cells are transported to the organs where they help improve overall functioning. Furthermore, individuals in Study 2 reported lower levels of stress and a better ability to recover at the end of the week (Schobersberger et al., 2010). This study is an excellent example of the practical benefits associated with moderate hiking. The physiological effects reported by studies like Lee et al. (2004) and Schobersberger et al. (2010) have been partially explained in a recent paper by Urdampilleta et al. (2012). Urdampilleta and colleagues (2012) discuss recent medical work on the subject of combining exercise with intermittent hypoxia (oxygen deprivation) in the treatment of obesity and the prevention of diabetes. Numerous laboratory and field studies have provided corroborating evidence suggesting that intermittent hypoxia during exercise can improve insulin sensitivity and help the body make better use of the nutrition it receives (Urdampilleta et al., 2012). This finding demonstrates a health benefit that is unique to recreation in a mountainous environment. While more conventional exercises are advantageous to overall health, activities like mountain hiking and mountain climbing provide the additional benefit of reduced oxygen availability.

Hiking has also been linked to the regulation of cholesterol in the blood of participants through a combination of physical activity and the logistical dietary restrictions associated with long-range trips. Backpacking is the term used to describe long-range unsupported hiking trips. Backpacking has been shown to be a good alternative to medication for the regulation of plasma-lipoproteins, otherwise known as cholesterol. In particular a study by Faber, Benade, Celliers, and Marais (1992) looked at the ways that backpacking impacts cholesterol through a combination of exercise and dietary shifts. Participants took part in a 6-week South American backpacking expedition while keeping food journals and undergoing general physical examinations. Prior to the trip, all participants demonstrated a typical western diet, high in protein and fat and comparatively low in carbohydrates (Faber et al., 1992). Over the course of the trip diet shifted in accordance with the demands of backpacking. Less meat, fat, and cholesterol were consumed and a higher proportion of daily caloric needs were met via carbs. The result of this dietary shift in combination with extended daily exercise was a marked decrease in low-density lipoproteins (LDL) in the blood of participants (Faber et al., 1992). LDL is commonly known as “bad cholesterol” and has been linked to the buildup of plaques in the arteries. High-density lipoproteins (HDL) or “good cholesterol” remained stable, resulting in an improved ratio of HDL to LDL. This shift in blood chemistry combined with stable weight loss

resulting from physical activity led to significantly reduced risk of heart disease over the period of examination (Faber et al., 1992). These findings have been further supported by case study work undertaken by DeVoe, Israel, Lipsey, and Voyles (2009) who tracked the cholesterol of a single participant during a 118 day hike of the Appalachian Trail. Over the course of this long-range trip, the participant reduced their body-fat percentage, improved their ratio of muscle to body fat, and experienced a normalization of both HDL and LDL levels (DeVoe et al., 2009).

The previously outlined studies provide a strong body of evidence demonstrating the measurable physiological benefits associated with hiking. There is however, another component to physical health that many of these researchers have overlooked. An individual's perception of their own health can have powerful implications for motivation and outlook. With this in mind, Strauss-Blanche et al., (2004) evaluated the impact of hiking on the perceived health of 72 overweight men. Given the link between obesity and depression, perceived improvements in health within an overweight population could be a powerful catalyst for actual weight loss and improved fitness. Participants were assigned to 3-week vacation scenarios at either high (1,700m) or low (200m) altitude. They engaged in four 3-4 hour hikes each week. Perceived health was reported 2 weeks before the vacation, at the beginning and end of the vacation, and during a follow-up after seven weeks (Strauss-Blanche et al., 2004). Fitness, recreational ability, positive and negative mood, and social activities all demonstrated significant improvements over the course of the vacations. These perceived improvements to health were maintained in the follow up examinations. These effects occurred independent of altitude and other factors, suggesting that a person does not need to engage in overly strenuous activity to reap the benefits associated with hiking (Strauss-Blanche et al., 2004). An interesting effect that was noted was that occupationally active participants demonstrated a greater long-term benefit to perceived health than retired men. As previously discussed, perceived health is an important element of actual health. Individuals who feel better tend to be more active and create a self-fulfilling prophecy with regards to health.

Rock Climbing

The wealth of evidence supporting the notion that mountain hiking is beneficial to the health of participants has been mirrored in studies of rock climbing. Rock climbing places different demands on the bodies of those participating compared with hiking. While both sports impact the cardiovascular system, rock climbing requires more muscular strength and endurance. Both indoor and outdoor rock climbing have been shown to improve strength, cardiovascular fitness, psychological well-being, and even lead to advantageous hormonal responses. These findings are applicable to the health of both adults and children and suggest that rock climbing could be an exciting alternative to more conventional exercises.

A pioneering study that sought to evaluate the physiological effects of indoor rock climbing was undertaken in 1997 by Mermier, Robergs, McMinn, and Heyward. Fourteen experienced rock climbers (9 men and 5 women) performed 3 rock climbing trials on 3 indoor walls, each with an increasing level of difficulty. The "easy" trial was conducted on a 90 degree wall of the difficulty grade used in a typical warm-up, the moderate trial was at 106 degrees, and the difficult trial was on a horizontally overhanging 151 degree wall. Participants' expired air was collected and heart rate was measured continuously during the trials (Mermier et al., 1997).

Blood lactate was also measured. VO_2 (the ability of the body to make use of oxygen) and heart rate showed a unique relationship compared to the linear trend observed in analyses of running or cycling. Researchers concluded that rock climbing is an excellent activity for improving cardiovascular fitness and muscular endurance. They note that, since the relationship between VO_2 and heart rate does not follow the expected trend, traditional recommendations should not be applied to rock climbing programs aimed at improving fitness (Mermier et al., 1997). This unique response has been observed in other studies of rock climbers (Draper et al., 2010), suggesting that it is a real and significant consideration when evaluating the effectiveness of rock climbing as cardiovascular exercise.

Further work by Rodio et al. (2008) has provided support for the findings of Mermier et al. (1997) while asking the fundamental question: Is non-competitive rock climbing a good means by which to improve aerobic fitness? Participants were 13 (8 men, 5 women) experienced but non-competitive climbers able to climb routes of moderate difficulty. Maximal aerobic power (VO_{2peak}) and ventilatory threshold were measured in the lab and VO_2 and heart rate were measured during outdoor climbing sessions. These data were used to compute exercise intensity and energy expenditure. Exercise intensity was found to be 70% of the maximum for men and 72% for women. Energy expenditure was calculated to be 1000-1500 kcal/week. The aerobic profile for climbing sessions was classified as excellent to superior according to the standards of the American College of Sports Medicine. Rock climbing was, therefore, found to be a good activity for maintaining and improving cardiovascular fitness.

The previously mentioned study by Draper et al. (2010) is also an important one to consider in evaluating the effectiveness of rock climbing as a mean of exercise. Not only does this research support findings related to key physiological responses to rock climbing, but it compared the physical and psychological responses of two variations of the sport to see if one climbing method is more or less advantageous to health than the next (Draper et al., 2010). The two most popular forms of rock climbing are top-rope and lead climbing. Top-rope is distinct in that the climber is attached to a rope which is anchored at the top of the route. This means that falls are usually very short (a few inches to a few feet). In lead climbing, the climber attaches the rope to points of protection along the route itself as they climb. This means that fall distance is always twice the height of a climber above his or her last protection point. Lead climbing is widely considered to be the more advanced approach.

Draper et al. (2010) looked at a group of 9 intermediate climbers who were randomly assigned to 2 climbing trials. Participants also completed a separate VO_2 max test on a separate occasion. The two climbing trials were differentiated by the style of climbing used, either top-rope or lead climbing. Between the two trials, significant differences were observed with respect to climbing time, blood lactate concentration, and self-reported physical and mental demands associated with the climbs. The main conclusions the researchers drew were that lead climbing is more physically demanding than top-rope climbing and that the excess energy requirements associated with it were satisfied through anaerobic metabolism. Researchers also reported a disproportionate rise in heart rate relative to VO_2 max (Draper et al., 2010). This supports the finding that there is a unique metaboreflex response associated with rock climbing that may not be observed in other sports.

Rock climbing has also been linked to advantageous hormonal responses in participants. Sherk et al. (2011) looked at the hormone response of ten men engaged in bouts of high intensity rock climbing. The participants (aged 21-30) climbed laps on a single wall well below the highest difficulty grade they were capable of climbing. Participants climbed for 30 minutes or until exhaustion with an average climbing time of around 25 minutes. After each lap, heart rate was measured and following the exercise blood tests were taken. Testosterone, growth hormone, and cortisol were compared to pre-exercise levels (Sherk et al., 2011). Both testosterone and growth hormone showed significant responses to the exercise while cortisol did not. The authors cite the dramatic range of cortisol values and ability differences in the climbers as reasons why they did not observe an effect. Due to the hormonal response observed, the researchers conclude that bouts of high intensity climbing are an effective means by which to improve cardiovascular and muscular endurance and, subsequently, overall physical health (Sherk et al., 2011).

Finally, rock climbing has been shown to be a beneficial activity for both adults and children. A 2009 study by Balas et al. evaluated the physiological effects of an 8-week rock climbing program on a group of 50 youths. Participants took part in one or two 90 minute classes each week for eight weeks. Prior to participation, the children (aged 10-17) took part in a number of tests meant to assess their upper body strength and body composition. At the end of the program, the participants were split into a low volume and high volume group based on the total vertical distances they had climbed. The value of 320 meters served as the cut-off between the two groups. Strength and body composition tests were repeated and the two groups were compared (Balas et al., 2009). The average distance climbed was around 200 meters for the low volume group and nearly 600 meters for the high volume group. The high volume group showed dramatic improvements in upper body strength relative to the low volume group, improving 4-9 times more on the grip strength to body mass ratio test and improving 4-5 times more on the bent arm hang test meant to assess shoulder muscle endurance. The high volume group also demonstrated a reduction in their ratio of extra cellular mass to body cellular mass (Balas et al., 2009). This study shows that even non-intensive recreational climbing can have a significant positive effect on health in children in as little as 3 months.

Alpine Skiing

Several studies have provided support for the idea that alpine skiing is yet another recreational pursuit that offers significant health benefits to those who engage in it. Research has suggested that moderate participation in alpine skiing is easily tolerated by adults and that even elderly participants can reap significant benefits from this form of exercise. Alpine skiing also offers a means of outdoor recreation for the winter months, during which the previously outlined pursuits (hiking and rock climbing) may be restricted in their accessibility. Alpine skiing, like hiking and rock climbing, exerts the cardiovascular system thereby exercising the lungs and heart. Skiing is also comparable in the demands it places on major muscle groups in the lower body. Skiing however, is a much more fast-paced activity. As such, it requires the development of reflexes and fast-twitch muscle fibers, making it a unique experience for participants providing a unique collection of health benefits. It should be noted that alpine skiing is not entirely non-motorized in that participants frequently make use of lifts or other vehicles to convey them to the start of a route.

In a well-cited 1996 study, Kahn and colleagues sought to examine how well untrained middle-aged men would tolerate a week of moderately intense physical activity at moderate altitude. The particular activity they chose to examine was downhill skiing. Ten men, aged 46-59, underwent physical examinations prior to, during, and following a one week leisure alpine skiing trip (Kahn et al., 1996). Relative to control readings taken on Day 0, the men demonstrated significant increases in noradrenaline; exhibited reduced resting heart rates; and improved blood pressure. Following their week of skiing, the men's noradrenaline readings returned to normal, but they continued to demonstrate improved resting heart rates and blood pressure. The authors conclude that untrained participants are quite tolerant of strong physical excursion at altitude for an extended period of time and that downhill skiing could be safely included in a program meant to reduce cardiovascular risk (Kahn et al., 1996).

Further support to the conclusion that alpine skiing can reduce the risk of cardiovascular disease is provided by the Salzburg Skiing for the Elderly study (Niedersser et al., 2011). A Segment of this study examined the impact that a 12-week alpine skiing intervention had on a group of elderly participants with respect to cardiovascular risk factors (CVRFs). A total of 42 elderly participants were divided into either the intervention group (n = 22, 12 males, 10 females, age = 66.6, +/- 2.1 yrs) or a control group (n = 20, 10 males, 10 females, age = 67.3 +/- 4.4 yrs) who lived their lives as normal but were not allowed to ski. The guided skiing intervention offered 32 possible skiing days over the 12 week period (Niederseer, et al., 2011). Participants took part in an average of 28.5 days. The average length of time skied each day was 3.5 hours. CVRFs were evaluated before and after the 12 week period. No cardiac events occurred during ski sessions, suggesting that the elderly are able to tolerate the physical demands of alpine skiing. The intervention group demonstrated improved exercise capacity and decreased body fat compared to the control group. This suggests that downhill skiing can be an effective way to mitigate the risk factors associated with cardiovascular disease.

The benefits derived from alpine skiing, however, are not limited to the cardiovascular system. Continuing the work of Niederseer and colleagues (2011), Mueller et al. (2011) evaluated aerobic capacity, strength, power, and balance in the experimental population from the Salzburg Skiing for the Elderly study, previously described. Participants were again placed into either the intervention group or the control group with the former having taken part in the 12-week alpine skiing activity. At the end of the 12-week period, VO₂ max had improved by 7.2% in the intervention group, with no change in the control group. The intervention group also demonstrated a 6% increase in jump height, and a 16% increase in dynamic leg strength at the end of 12-weeks. The control group showed no change in leg strength and an 11.7% decline in jump height. These results demonstrate that, not only is alpine skiing useful in reducing cardiovascular risk factors, but it helps to improve general muscular fitness for those who engage in it. Improved fitness, especially in the elderly, has the potential to reduce doctor or hospital visits and reduce injuries caused by falls. Furthermore, improved strength can promote engagement in future activities, propagating continued benefits (Mueller et al., 2011).

Health Benefits of Being in Nature

Undoubtedly, participation in non-motorized outdoor recreation offers a multitude of health benefits; some activity specific (increased hormonal activation in rock climbers), others more general (improved cardiovascular capacity and fitness). One could argue, however, that participation in more urban-based activities might provide the same benefits with less risk to the individual. For this reason it is important to understand the health benefits derived simply from being present in a natural environment. Countless studies, both historical and recent, have begun to reveal the multitude of psychological, emotional, and physiological benefits that people derive merely by escaping the city. These attributes can be considered additional to those previously discussed as they come from the environment, independent of physical activity.

In a classic discussion of the restorative effects of nature, Kaplan (1995) outlines several studies that have examined the link between time spent in a natural setting and implications for human effectiveness, particularly pertaining to attention. To restore cognitive effectiveness, Kaplan argues, a setting must meet four criteria:

1. Being away – It allows a person to escape the sources of their daily stress.
2. Fascination – It must hold a person's interest without much effort. - Kaplan stresses the advantages of nature in this regard, in that elements of nature engage people in “passive fascination.”
3. Extent – It must be perceived to have vastness.
4. Compatibility – It must fit with a person's disposition.

Kaplan (1995) cites three studies that have examined the impact of time spent in nature on performance of demanding cognitive tasks. In the first study, Hartig et al. (1991a) compared wilderness vacationers with urban vacationers with respect to their performance on a proof reading task. Only fit people with backpacking experience were included in the study. The wilderness vacation group showed significant improvements on the proof-reading task while the urban group declined in their performance. Wilderness vacationers also reported the highest overall happiness. In another study by Hartig et al. (1991b), participants were randomly placed into one of three groups. The first two groups spent 40 minutes walking in either a natural or urban setting, the third group listened to peaceful music for 40 minutes. The nature walking group outperformed the other two groups on a subsequent proofreading task and reported feeling more rejuvenated than the other groups. Finally, Kaplan cites a study by Cimprich (1992) that examined the attentional capacity of recovering cancer patients. Patients who took part in restorative activities in a natural setting showed significant improvements with respect to attention and were significantly more likely to return to work. They were also more likely to take up new goals such as improving their physical fitness.

The health benefits of a natural setting are not limited to the mind, however. A number of studies by Japanese researchers into the idea of Shinrin Yoko (literally “forest bathing”) suggest that there may be additional health benefits to the immune system. Researchers compared psychological and physiological response data from groups of participants who were assigned to 3-day, 2-night excursions in either a natural or an urban setting. In addition to the psychologically restorative effects described by Kaplan, data suggested reduced stress hormones in the bodies of participants in the natural setting condition as well as a lower resting heart rate

(Lee, et al., 2011). Similar studies have found increased presence of “natural killer cells” in the blood of people who spent time in natural environments. Natural killer cells (NKC) are a part of the body’s response to invading pathogens like viruses and bacteria (Li et al., 2008a; Li et al., 2008 b). Researchers also found increased numbers of anti-cancer proteins in the body after time spent in nature. The active agent in this immune system response is thought to be airborne chemicals called phytoncides, which are released by trees (Li, et al., 2006). Recent research has suggested that a specific phytoncide called alpha-pinene can reduce tumor growth in mice when introduced as an aromatherapeutic treatment (Kusuhara et al., 2012).

Conclusion

Given the apparent economic consequences of physical inactivity, it is important to provide the public with access to recreation that can improve health and prolong lives. Sufficient evidence exists to implicate non-motorized outdoor recreation activities as a possible means through which to encourage physical fitness. Several general health benefits such as improved cardiovascular fitness, reduced body fat, and improved strength can be accrued through participation in any of the possible activities. Other health benefits like improved insulin sensitivity, and hormonal responses are specific to various activity forms. In addition to simply providing exercise, non-motorized outdoor recreation encourages participants to visit natural settings. This behaviour alone has been associated with unique physical benefits. Research into the body’s immune system response to chemicals released by trees suggests that physical activity undertaken in a natural setting has the potential to provide two unique mechanisms by which to improve health. Time spent outside of an urban setting has also been shown to have a restorative effect on mental processes, leading to an improved outlook and a heightened potential to engage in further recreation. Once the cycle of improved health begins to take hold on a person, it creates a self-perpetuating pattern of positive behavioural choices. Extrapolated into the long-term and across a broad scale, non-motorized outdoor recreation has the potential to not only improve the quality of life of all Canadians, but it may ultimately help strengthen the national economy.

Annotated Bibliography

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This work formed a large part of the foundation for the review of health benefits associated with recreation discussed in Kline, Rosenberger, and White (2011) and is useful in this review for the same reasons. This work compiles an extensive list of common physical activities and provides statistics for each along with equations necessary for computing the energy expenditure associated with the activities. This allows for a comparison between outdoor recreation, athletic training, leisure, and any other form of activity one might care to consider. Activities are compared with respect to energy expenditure using MET (metabolic equivalent) values meant to indicate the ratio of energy use between the mentioned activity and rest for a person of a given body weight. Energy expenditure is estimated in kilocalories and MET values directly correspond to this measure. For example, if an activity has an MET value of 2, it required twice the metabolic energy consumption of sitting quietly. Backpacking has an MET value of 7.0, Rock or Mountain Climbing has an MET value of 8.0. These values are directly comparable with jogging at a reasonable pace (5 mph) (MET =8.0), playing basketball (MET = 8.0), or playing hockey (MET = 8.0). Motorized activities have much lower energy requirements. For example motocross was assigned a MET of 4.0.

Balas, J., Strejcova, B., Maly, T., Mala, L., & Martin, A. J. (2009). Changes in upper body strength and body composition after 8 weeks indoor climbing in youth. *Isokinetics and Exercise Science*, 17(3), 173-179. doi:10.3233/IES-2009-0350

This study evaluated the physiological effects of an 8-week rock climbing program on a group of 50 youths. Participants took part in one or two 90 minute classes each week for eight weeks. Prior to participation, the children (aged 10-17) took part in a number of tests meant to assess their upper body strength and body composition. At the end of the program, the participants were split into a low volume and high volume group based on the total vertical distances they had climbed. The value of 320 meters served as the cut-off between the two groups. The strength and body composition tests were repeated and the two groups were compared. The average distances climbed were around 200 meters for the low volume group and nearly 600 meters for the high volume group. The high volume group showed dramatic improvements in upper body strength relative to the low volume group, improving 4-9 times more on the grip strength to body mass ratio test and improving 4-5 times more on the bent arm hang test meant to assess shoulder muscle endurance. The high volume group also demonstrated a reduction in their ratio of extra cellular mass to body cellular mass. Neither group showed a significant change in body fat content. This study shows that even non-intensive recreational climbing can have a significant positive effect on health in children in as little as 3 months.

Bauman, A., Madill, J., Craig, C., & Salmon, A. (2004). ParticipACTION - this mouse roared, but did it get the cheese? *Canadian Journal of Public Health-Revue Canadienne De Sante Publique, 95*, S14-S19.

This article discusses the actual measured effects of the ParticipACTION campaign. It provides good context for the Rootman and Edwards (2004) article, and would likely precede it in the discussion regarding the promotion of physical activity in BC. The most impressive statistics it presents are that between 1980 and 2002, 80% of Canadians surveyed were aware of the campaign and could identify its logo. This proportion compares favorably against a similar campaign attempted in the UK which results in on 38% awareness and no effect of physical activity in the population (Hillsdon et al., 2001). Conversely, 7% of Canadians indicated that ParticipACTION had a positive impact on their level of physical activity, with no prompting from the survey. In Quebec, the proportion was closer to 10%. When explicitly asked whether the program had influenced them to be more active, 64% of Canadians agreed that it had. This article, presented in tandem with Rootman and Edwards (2004) presents a strong case for the likely success of a BC campaign aimed at promoting outdoor recreation.

DeVoe, D., Israel, R. G., Lipsey, T., & Voyles, W. (2009). A long-duration (118-day) backpacking trip (2669 km) normalizes lipids without medication: A case study. *Wilderness & Environmental Medicine, 20*(4), 347-352.

DeVoe et al. provide an analysis of the impacts of long range backpacking on the health of a single individual. Though the validity of the study can easily be called into question by the fact that one of the researchers was the study's sole participant, the objective nature of the results measured are still useful in determining the nature of real effects. Several measures of body composition were taken before, during, and after a 2,669 km, 118 day hike along the Appalachian Trail. Not surprisingly, five months of consistent hiking led to dramatically decreased body weight, a higher muscle-to-body fat ratio, normalization of blood lipids and a range of other positive outcomes. A brief discussion of the increased caloric demands associated with cold weather exercise is provided. The fact that more calories are required simply to maintain a comfortable body temperature is a useful finding in the context of BC recreation as many outdoor enthusiasts engage in winter activities like skiing and snowshoeing. The general finding of improved health presented by this study is also useful but must be considered with the caveat of the questionable methodology.

Draper, N., Jones, G. A., Fryer, S., Hodgson, C. I., & Blackwell, G. (2010). Physiological and psychological responses to lead and top rope climbing for intermediate rock climbers. *European Journal of Sport Science, 10*(1), 13-20. doi:10.1080/17461390903108125

This study examined differences in physiological and psychological responses to difference styles of climbing on the same route. A group of 9 intermediate climbers were randomly assigned to 2 climbing trials and completed a separate VO₂ max test on a separate occasion. The two climbing trials were differentiated by the style of climbing used, either top-rope or lead climbing. Between the two trials, significant differences were observed with respect to climbing time, blood lactate concentration, and self-reported physical and mental demands associated with

the climbs. The main conclusions the researchers drew were that lead climbing is more physically demanding than top-rope climbing and that the excess energy requirements associated with it were satisfied through anaerobic metabolism. Researchers also reported a disproportionate rise in heart rate relative to VO_2 max. This suggests that there is a unique mataboreflex response associated with rock climbing that may not be observed in other sports. This paper is important because it demonstrates the uniqueness of seemingly similar activities. It makes a strong case for access to a range of difference recreational areas to promote all types of experience and to allow enthusiasts to reap the full range of health benefits associated with new challenges.

Faber, M., Benade, A., Celliers, C., & Marais, M. (1992). Changes in plasma-lipoprotein levels during a hiking expedition in South-America. *International Journal of Sports Medicine*, 13(4), 279-284. doi:10.1055/s-2007-1021267

This study looked at the ways that backpacking impacts cholesterol through a combination of exercise and dietary shifts. Participants took part in a 6-week South American backpacking expedition while keeping food journals and undergoing general physical examinations. Prior to the trip, all participants demonstrated a typical western diet, high in protein and fat and comparatively low in carbohydrates. Over the course of the trip diet shifted in accordance with the demands of backpacking. Less meat, fat, and cholesterol were consumed and a higher proportion of daily caloric needs were met via carbs. As a result of this dietary shift in combination with extended daily exercise (hiking) the participants demonstrated a marked decrease in low-density lipoproteins (LDL) in their blood. LDL is commonly known as “bad cholesterol” and has been linked to the buildup of plaques in the arteries. High-density lipoproteins (HDL) or “good cholesterol” remained stable, resulting in an improved ratio of HDL to LDL. This shift in blood chemistry combined with stable weight loss resulting from physical activity led to significantly reduced risk of heart disease over the period of examination.

Fredrickson, L., & Anderson, D. (1999). A qualitative exploration of the wilderness experience as a source of spiritual inspiration. *Journal of Environmental Psychology*, 19(1), 21-39. doi:10.1006/jevp.1998.0110

This qualitative study used on-site observation, personal field journals, and in-depth interviews to assess the impact of time spent in a wilderness setting on personal feelings and motivations. Two groups of women participated in one of two wilderness recreation trips either canoeing or hiking in the Grand Canyon. Participants kept journals which were analyzed and used to develop interview questions. Within three weeks of each trip, interviews took place. Participants generally commented on the vastness and power of nature they perceived and reported feeling inspired by the time they spent in the wilderness. Interpersonal interactions combined with immersion in the natural landscape increased the likelihood of feeling inspired. This work relates to some of the other psychological research and the personal nature adds to the depth of the literature review.

Hakim, A., Curb, J., Petrovitch, H., Rodriguez, B., Yano, K., Ross, G., White, L.R., Abbott, R. (1999). Effects of walking on coronary heart disease in elderly men - the Honolulu heart program. *Circulation*, 100(1), 9-13.

This famous study was funded in part by the American Heart Association and looked at the risk of coronary heart disease in elderly men who walked various distances. Distance walked was evaluated in 2,678 men (ages 71 – 93) at baseline examinations between 1991 and 1993 as part of the Honolulu Heart Program. Instances of coronary heart disease were observed over a 2 to 4 year follow up. Men who walked less than 0.25 miles/d were found to exhibit twice the risk of developing heart disease compared with men who walked more than 1.5 miles/d. Both of these groups were also significantly more likely to develop heart disease than men who walked even further. These results were taken to suggest that walking is a good way to maintain cardiovascular fitness. This study has been cited countless times since its publication and indicates that the advantageous effects of recreational exercise are not limited by age.

Humpel, N., Owen, N., & Leslie, E. (2002). Environmental factors associated with adults' participation in physical activity - A review. *American Journal of Preventive Medicine*, 22(3), 188-199. doi:10.1016/S0749-3797(01)00426-3

This paper evaluated the factors that contribute to adults' decisions to undertake physical activity in a particular setting. The work reviews 19 studies and aims to assess the importance of a number of factors in determining individual likelihood to engage in physical activity. The parameters of interest were: accessibility, opportunities for activity, weather, safety, and aesthetics. Accessibility, opportunities and aesthetics all had significant associations with physical activity. This implies that an area that can combine scenic beauty, infrastructure, and accessibility will be highly effective in promoting physical activity. Natural protected areas present an excellent opportunity in this regard. The previously outlined psychological benefits associated with time spent in nature, combined with the multitude of recreational opportunities present in protected areas presents an ideal situation for promoting physical activity. This relates not only to the discussion of overcoming the problem of inactivity, but it provides a nice link to the specific health benefits associated with various recreational activities.

Huonker, M., Schmidt-Trucksass, A., Soricter, S., Irmer, M., Durr, H., Lehmann, M., & Keul, J. (1997). Highland mountain hiking and coronary artery disease: Exercise tolerance and effects on left ventricular function. *Medicine and Science in Sports and Exercise*, 29(12), 1554-1560. doi:10.1097/00005768-199712000-00002

This study compared the intensity of mountain hiking (8.7 km, from 470m – 1220m above sea level) with the corresponding data from a multistage upright cycling session. Eleven men with stable coronary artery disease were compared to 9 healthy controls with respect to several measures of intensity. The coronary artery disease group showed significantly improved function of damaged arteries during both exercises. The workload associated with mountain hiking was equivalent to 100-120 Watts on the upright cycle. The authors conclude that hiking could be considered a safe alternative to more conventional means of exercise with respect to the cardiovascular benefits that it offers. This study serves the purpose of this literature review quite well in that it provides a direct comparison between the health benefits associated with hiking

and those provided by more conventional exercise. The comparison is favorable in this case. The fact that people can meet their exercise needs through hiking, combined with the psychological benefits of time spent in nature, suggests that non-motorized outdoor recreation is ideally suited to the well-being of people.

Janssen, I. (2012). Health care costs of physical inactivity in Canadian adults. *Applied Physiology, Nutrition, and Metabolism*, 37, 1-4.

This study attempted to estimate the Canadian health care costs associated with physical inactivity. The method used was a prevalence-based approach that made use of three pieces of information:

1. The risk of chronic conditions in physically inactive people
2. The direct and indirect costs associated with diseases linked to physical inactivity
3. The prevalence of physical inactivity in the population

Seven chronic diseases were used for the analysis after determining their high correlations with a physically inactive lifestyle. They were: coronary artery disease, stroke, hypertension, colon cancer, breast cancer, Type 2 diabetes, and osteoporosis. The rate of physical inactivity was taken from the Canadian Health Measures Study (2009). Physical inactivity was defined as engaging in less than 150 minutes of moderate to vigorous physical activity each week. The rate of physical inactivity was 82.9% for men and 86.3% for women. The Canadian Health care costs associated with this were estimated to be \$6.8 billion (\$2.4 billion in direct costs, \$4.3 billion in indirect costs).

Kahn, J., Jouanin, J., Bruckert, E., Guezennec, C., & Monod, H. (1996). Physiological effects of downhill skiing at moderate altitude in untrained middle-aged men. *Wilderness & Environmental Medicine*, 7(3), 199-207. doi:10.1580/1080-6032(1996)007[0199:PEODSA]2.3.CO;2

Kahn and colleagues sought to examine how well untrained middle-aged men would tolerate a week of moderately intense physical activity at moderate altitude. The particular activity they chose to examine was downhill skiing. Ten men, aged 46-59, underwent physical examinations prior to, during, and following a one week leisure alpine skiing trip. Relative to control readings taken on Day 0, the men demonstrated significantly increased levels of noradrenaline, but not adrenaline; exhibited reduced resting heart rates; and improved blood pressure. Following the their week of skiing, the men's noradrenaline readings returned to normal, but they continued to demonstrate improved resting heart rates and blood pressure. The authors conclude that untrained participants are quite tolerant of strong physical excursion at altitude for an extended period of time and that downhill skiing could be safely included in a program meant to reduce cardiovascular risk. This study gives a terrific example of the specific health benefits associated with a winter, non-motorized, alpine-based activity.

Kaplan, S. (1995). The restorative benefits of nature - toward an integrative framework. *Journal of Environmental Psychology, 15(3), 169-182. doi:10.1016/0272-4944(95)90001-2*

In this paper, Kaplan discusses several studies that have examined the link between time spent in nature and restorative implications for human effectiveness, particularly pertaining to attention. To restore cognitive effectiveness, Kaplan argues, a setting must meet four criteria:

1. Being away – It allows a person to escape the sources of their daily stress.
2. Fascination – It must hold a person’s interest without much effort. Kaplan stresses the advantages of nature in this regard in that elements of nature engage people in “passive fascination.” When we are engaged in nature it is usually in a non-dramatic way. He is essentially describing non-motorized activities exclusively.
3. Extent – It must be perceived to have vastness.
4. Compatibility – It must fit with a person’s disposition.

Kaplan cites three studies that have examined the impact of time spent in nature on performance on demanding cognitive tasks. In the first study, Hartig et al. (1991) compared wilderness vacationers with urban vacationers with respect to their performance on a proof reading task. Only fit people with backpacking experience were included in the study. The wilderness vacation group showed significant improvement on the proof-reading task while the urban group declined in their performance. Wilderness vacationers also reported the highest overall happiness. In another study by Hartig et al. (1991), participants were placed into one of three groups. The first two groups spent 40 minutes walking in either a natural or urban setting, the third group listened to peaceful music for 40 minutes. The nature walking group outperformed the other two groups on a subsequent proofreading task and reported feeling more rejuvenated than the other groups. Finally, Kaplan cites a study by Cimprich (1992) that examined the attentional capacity of recovering cancer patients. Patients who took part in restorative activities in a natural setting showed significant improvements with respect to attention and were significantly more likely to return to work. They were also more likely to take up new goals like getting in shape.

Kline, J. D., Rosenberger, R. S., & White, E. M. (2011). A national assessment of physical activity in US National Forests. *Journal of Forestry, 109(6), 343-351.*

This paper is a national assessment of physical activity in US National Forests with specific regard to the impact these activities have on the health of the American population. The authors calculated the energy expenditure associated with outdoor recreation in US parks and concluded that these activities are likely a significant source of overall physical activity. Estimates were based on the number of visit hours reported for various activities in the National Visitor Use Monitoring program as well as energy expenditure estimates indicated by Ainsworth et al. (1994). This paper will be incredibly useful in the current literature review as it targets the exact subject being reviewed, outdoor recreation and the associated health benefits.

Kusuhara, M., Urakami, K., Masuda, Y., Zangiacomi, V., Ishii, H., Tai, S., Maruyama, K., Yamaguchi, K. (2012). Fragrant environment with alpha-pinene decreases tumor growth in mice. *Biomedical Research-Tokyo*, 33(1), 57-61.

This recent work by an independent research team supported the findings of Li et al. (2006) with respect to immune responses associated with phytoncides. In this study, cancerous lab rats were placed either in an environment enriched with α -pinene (a common phytoncide released by trees) or in a control environment. Rats in the presence of α -pinene exhibited tumors 40% smaller than those in the control environment. These results, however, were not observed when cancer cells were treated with α -pinene in vitro, suggesting that the effect is not direct. This independent duplication of findings presented previously lends support to the conclusions of Li, et al. in their studies of forest bathing on immune responses.

Lee, J., Park, B., Tsunetsugu, Y., Ohira, T., Kagawa, T., & Miyazaki, Y. (2011). Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. *Public Health*, 125(2), 93-100. doi:10.1016/j.puhe.2010.09.005

This study examined the effect of “forest bathing” on the physiological and psychological responses of young Japanese males. Participants engaged in a 3-day 2-night field experiment in which they traveled to a forest environment where they underwent several physiological and psychological tests. Compared with baseline data collected in an urban environment, the men exhibited reduced salivary cortisol (stress) levels and a reduction in heart rate variability. Participants responses to stimuli were also altered in the forest environment with their positive responses to stimuli being magnified and their negative responses being weakened. The authors conclude that the mere act of being in a forest reduces physiological stress, improves mood, and better responses to stimuli. There is a wealth of literature surrounding the practice of forest bathing that provided uniquely concrete data suggesting its health benefits.

Lee, W., Chen, J., Hunt, D., Hou, C., Lai, Y., Lin, F., . . . Kuo, C. (2004). Effects of hiking at altitude on body composition and insulin sensitivity in recovering drug addicts. *Preventive Medicine*, 39(4), 681-688. doi:10.1016/j.ypmed.2004.02.035

Lee et al. examined the physical health impacts of long-range hiking on a group of recovering drug addicts. Prior to their participation in the study, participants had demonstrated 13 – 100% increases in body weight and a trend toward insulin resistance as a result of their recovery from drug addiction. Nine men participated in the hiking therapy which consisted of 25 days spent hiking at altitudes between 2,200 and 3,800 meters. On day 25, the men were compared to 17 healthy controls on a number of measures of physical health. Insulin sensitivity was found to have normalized over the course of the expedition, and the men showed marked improvements in both Waist-to-Hip ratio and lean body mass. The authors conclude that participating in physical activity at altitude has a restorative effect on insulin sensitivity and speculate that this effect is due, at least in part, to a reduction in central fatness. This study provides evidence for how non-motorized outdoor recreation, particularly at altitude, can be used to restore damaged health to normal levels in a relatively short period of time.

Li, Q., Morimoto, K., Kobayashi, M., Inagaki, H., Katsumata, M., Hirata, Y., . . . Miyazaki, Y. (2008a). A forest bathing trip increases human natural killer activity and expression of anti-cancer proteins in female subjects. *Journal of Biological Regulators and Homeostatic Agents*, 22(1), 45-55.

This study found that time spent walking in a forest environment improved the immunological responses of a group of 13 Japanese women. Participants spent 3 days and 2 nights in a forest environment where they participated in 2 h walks in the morning and evening. Blood tests revealed that the presence and activity of “natural killer cells” was enhanced by time spent in the forest. Natural killer cells are part of the body’s immune system. They help fight viruses and infections and have been linked to anti-cancer responses. The effects of time spent in the forest environment were present up to 7 days following the trip. The authors suggest that decreased stress levels and the presence of chemicals released from trees (called phytoncides) might be responsible for the observed immunological responses.

Li, Q., Morimoto, K., Kobayashi, M., Inagaki, H., Katsumata, M., Hirata, Y., . . . Krensky, A. M. (2008b). Visiting a forest, but not a city, increases human natural killer activity and expression of anti-cancer proteins. *International Journal of Immunopathology and Pharmacology*, 21(1), 117-127.

In this study, the same research team previously mentioned duplicated their results with respect to increased Natural Killer cell presence and activity in a group of Japanese men. Researchers took the study one step further, however, and attempted direct comparisons between responses to forest trips and urban tourist trips. The immunological responses previously associated with time spent walking in the forest were again observed. The same responses were not seen following time spent walking in an urban environment. Researchers collected air samples and analyzed them for the presence of phytoncides (chemicals released from trees) and found high concentrations in the forest air and a near absence of these chemicals in the urban environment. These findings lend credence to the idea that phytoncides are beneficial to the human immune system by promoting natural killer cell formation and activity.

Li, Q., Nakadai, A., Matsushima, H., Miyazaki, Y., Krensky, A. M., Kawada, T., & Morimoto, K. (2006). Phytoncides (wood essential oils) induce human natural killer cell activity. *Immunopharmacology and Immunotoxicology*, 28(2), 319-333. doi:10.1080/08923970600809439

This laboratory study conducted by the research team mentioned previously forms the basis for their hypothesis regarding the influence of phytoncides in human immunological activity. This study directly examined the impact of chemicals present in phytoncides on the activity of natural killer cell lines. Results support the idea that phytoncides increase the activity of these cells. This hard science approach lends strong support to the health benefits of time spent in forested environments.

Li, Q., Otsuka, T., Kobayashi, M., Wakayama, Y., Inagaki, H., Katsumata, M., . . . Kagawa, T. (2011). Acute effects of walking in forest environments on cardiovascular and metabolic parameters. *European Journal of Applied Physiology*, 111(11), 2845-2853. doi:10.1007/s00421-011-1918-z

In this study Li et al. examined the cardiovascular and metabolic effects associated with time spent walking in a forest environment. Not surprisingly, they found that blood pressure and noradrenaline levels were significantly reduced following time spent walking in a forest environment. Walking exercise in general was also found to improve metabolic responses, whether it took place in an urban or forested environment. This study only served to strengthen the evidence that time spent walking in a forest is beneficial to health in ways other than those previously described by this group of researchers. Taken together, these studies form a persuasive case for why humans should spend as much time as possible in natural environments. The fact that natural airborne chemicals can have such profound positive impacts on health in such a variety of ways indicates the importance of outdoor recreation overall. The fact that these experiments were carried out using activities that reduce stress, implies that the observed benefits might be impaired by motorized activities, which generally aim to increase arousal and sympathetic nervous system responses. This runs counter to the hypothesis presented by Li et al. 2008 that increased activity of the parasympathetic nervous system is a likely factor in promoting the immune system benefits they describe.

Mermier, C., Robergs, R., McMinn, S., & Heyward, V. (1997). Energy expenditure and physiological responses during indoor rock climbing. *British Journal of Sports Medicine*, 31(3), 224-228.

This was a pioneering study of physiological responses to rock climbing. Fourteen experienced rock climbers (9 men and 5 women) performed 3 rock climbing trials on 3 indoor walls. Each trial had an increasing level of difficulty. The easy trial was on a 90 degree wall, the moderate trial was at 106 degrees, and the difficult trial was on a horizontally overhanging 151 degree wall. Expired air was collected and heart rate as measured continuously during the trials. Blood lactate was also measured. VO_2 and heart rate showed a unique relationship compared to the linear trend observed for running or cycling. Researchers concluded that rock climbing is an excellent activity for improving cardiovascular fitness and muscular endurance. They note that, since the relationship between VO_2 and heart rate does not follow the expected trend, traditional recommendations should not be applied to rock climbing programs aimed at improving fitness. This study is important because it set the stage for many of the others cited in this bibliography. It was the first study to demonstrate the VO_2 and heart rate relationship observed by Draper et al. 2010 and implies that it is a well-established fact that rock climbing promotes good cardiovascular health.

Mueller, E., Gimpl, M., Kirchner, S., Kroell, J., Jahnel, R., Niebauer, J., Niederseer, D. Scheiber, P. (2011).: Influence of alpine skiing on aerobic capacity, strength, power, and balance. *Scandinavian Journal of Medicine & Science in Sports*, 21, 9-22. doi:10.1111/j.1600-0838.2011.01337.x

This study built on the work described previously by Niederseer et al (2011) by evaluating aerobic capacity, strength, power, and balance in the experimental population previously described. Participants were placed into either the intervention group or the control group where the intervention group took part in the 12-week alpine skiing activity. At the end of the 12-week period, VO₂ max improved by 7.2% in the intervention group, with no change in the control group. The intervention group also demonstrated a 6% increase in jump height, and a 16% increase in dynamic leg strength at the end of 12-weeks. The control group showed no change in leg strength and an 11.7% decline in jump height. These results demonstrate that, not only is alpine skiing useful in reducing cardiovascular risk factors, but it helps to improve general muscular fitness for those who engage in it. Improved fitness, especially in the elderly, has the potential to reduce doctor or hospital visits and reduce injuries caused by falls. Furthermore, improved strength can promote engagement in future activities, propagating continued benefits.

Niederseer, D., Ledl-Kurkowski, E., Kvita, K., Patsch, W., Dela, F., Mueller, E., & Niebauer, J. (2011). Salzburg skiing for the elderly study: Changes in cardiovascular risk factors through skiing in the elderly. *Scandinavian Journal of Medicine & Science in Sports*, 21, 47-55. doi:10.1111/j.1600-0838.2011.01341.x

This study examined the impact that a 12-week alpine skiing intervention had on a group of elderly participants with respect to cardiovascular risk factors (CVRFs). A total of 42 elderly participants were divided into either the intervention group (n = 22, 12 males, 10 females, age = 66.6, +/- 2.1 yrs) or a control group (n = 20, 10 males, 10 females, age = 67.3 +/- 4.4 yrs) who lived their lives as normal but were not allowed to ski. The guided skiing intervention offered 32 possible skiing days over the 12 week period and the participants averaged 28.5 days. The average length of time skied each day was 3.5 hours. CVRFs were evaluated before and after the 12 week period. No cardiac events occurred during ski sessions, suggesting that elderly people are able to tolerate the physical demands of alpine skiing. The intervention group demonstrated improved exercise capacity and decreased body fat compared to the control group. This study demonstrates that downhill skiing can be an effective way to mitigate the risk factors associated with cardiovascular disease. Since heart disease in general is such a large concern in modern society, it is important to recognize the potential for skiing to improve health in this way.

Rodio, A., Fattorini, L., Rosponi, A., Quattrini, F. M., & Marchetti, M. (2008). Physiological adaptation in noncompetitive rock climbers: Good for aerobic fitness? *Journal of Strength and Conditioning Research*, 22(2), 359-364. doi:10.1519/JSC.0b013e3181635cd0

This study addressed the question, does non-competitive rock climbing fulfill sports medicine recommendations for maintaining good aerobic fitness. Participants in the study were 13 (8 men, 5 women) experienced but non-competitive climbers able to climb routes of moderate difficulty. Each participant indicated that rock climbing was the only sport they engaged in

regularly. Maximal aerobic power (VO₂peak) and ventilatory threshold were measured in the lab and VO₂ and heart rate were measured during outdoor climbing sessions. These data were used to compute exercise intensity and energy expenditure. Exercise intensity was found to be 70 +/- 6% for men and 72 +/- 8% for women. Energy expenditure was calculated to be 1000-1500 kcal/week. The aerobic profile for climbing sessions was classified as excellent to superior according to the standards of the American College of Sports Medicine. Rock climbing was, therefore, found to be a good activity for maintaining and improving cardiovascular fitness.

Rootman, I., & Edwards, P. (2004). The best laid schemes of mice and men ... - ParticipACTION's legacy and future of physical activity promotion in Canada. *Canadian Journal of Public Health-Revue Canadienne De Sante Publique, 95*, S37-S42.

This paper discusses the hugely popular Canadian physical activity campaign called ParticipACTION. It focuses largely on the legacy of the program as perceived by a group of experts in the field. ParticipACTION remains largely prevalent in the Canadian consciousness, but this article suggests that further work is needed to make sure that its effects do not die out. The message the authors present is that ParticipACTION has built a strong foundation for future campaigns to build on. It has engrained physical activity into the Canadian consciousness and created a culture that is primed for further encouragement. This study demonstrates how people can respond positively toward campaigns promoting physical activity. The pervasive feelings regarding participation make it appealing for politicians to pursue similar initiatives in the future.

Roux, A. V. D., Evenson, K. R., McGinn, A. P., Brown, D. G., Moore, L., Brines, S., & Jacobs, D. R., Jr. (2007). Availability of recreational resources and physical activity in adults. *American Journal of Public Health, 97*(3), 493-499. doi:10.2105/AJPH.2006.087734

This study examined whether or not the availability of recreational resources was a factor in adult physical activity levels. Data from over 2700 middle aged participants living in the Northeastern United States were linked to the location of recreational resources. Researchers looked at the availability of resources within a 0.5, 1, 2, and 5 mile radius and looked for associations with physical activity. Participants in the areas with the highest density of resources were significantly more likely to report being physically active. Associations were found for the 1 to 5 mile distances. These findings suggest that making activity available to people increases their likelihood of participation.

Schobersberger, W., Leichtfried, V., Mueck-Weymann, M., & Humpeler, E. (2010). Austrian moderate altitude studies (AMAS): Benefits of exposure to moderate altitudes (1,500-2,500 m). *Sleep and Breathing, 14*(3), 201-207. doi:10.1007/s11325-009-0286-y

The work reported in this paper is part of the larger Austrian Moderate Altitude Study. The specific effects of active vacations at altitude were examined following a pilot study that suggested 3-week vacations at altitude offer numerous benefits to health. The main effects observed were reduced heart rate, blood pressure, and insulin resistance. For the main study, 71 participants took part in 3-week simulated vacations at either low or moderate altitude. The

vacations included 3-4 hour guided hikes, relaxation and rejuvenation in hotel spas, and no dietary restrictions. Both groups showed a significant reduction in blood pressure, body weight, body fat, reduced total cholesterol, and improved perceived health. Part two of the study involved 16 healthy participants who spent one week at a four star hotel at 1700 m elevation. The vacation included 5 guided hiking tours of moderate intensity. The participants had no dietary restrictions. Results from study 2 strongly support those found in study 1 and provided additional insights. Participants demonstrated an increase in the number of adult progenitor cells circulating in their blood. These stem cells are transported to the organs where they help improve functioning. Furthermore, individuals in study 2 reported lower levels of stress and a better ability to recover at the end of the week. This detailed study outlined the practical benefits associated with a realistic amount of outdoor recreation. It has high external validity and its design is useful in translating the findings to BC.

Sherk, V. D., Sherk, K. A., Kim, S., Young, K. C., & Bemben, D. A. (2011). Hormone responses to a continuous bout of rock climbing in men. *European Journal of Applied Physiology*, 111(4), 687-693. doi:10.1007/s00421-010-1685-2

This study looked at the hormone response of ten men engaged in bouts of high intensity rock climbing. The participants (aged 21-30) climbed laps on a single wall well below their highest difficulty grade. Participants climbed for 30 minutes or until exhaustion with an average climbing time of around 25 minutes. After each lap, heart rate was measured and following the exercise blood samples were taken. Testosterone, growth hormone, and cortisol were compared to pre-exercise levels. Both testosterone and growth hormone showed significant responses to the exercise while cortisol did not. The authors cite the dramatic range of cortisol values and ability differences in the climbers as reasons why they did not observe an effect. Due to the hormonal response observed, the researchers conclude that bouts of high intensity climbing are an effective means by which to improve cardiovascular and muscular endurance and, subsequently, overall physical health.

Strauss-Blasche, G., Riedmann, B., Schobersberger, W., Ekmekcioglu, C., Riedmann, G., Waanders, R., . Humpeler, E. (2004). Vacation at moderate and low altitude improves perceived health in individuals with metabolic syndrome. *Journal of Travel Medicine*, 11(5), 300-306.

This study examined the effect of hiking vacations on symptoms of metabolic syndrome in 72 overweight men. Participants were assigned to 3-week vacation scenarios at either high (1,700m) or low (200m) altitude. They engaged in four 3-4 hour hikes each week. Perceived health was reported 2 weeks before the vacation, at the beginning and end of the vacation, and seven weeks afterwards. Fitness, recreational ability, positive and negative mood, and social activities all demonstrated significant improvements over the course of the vacations. These perceived improvements to health were maintained in the follow up examinations. These effects occurred independent of altitude and other factors, suggesting that a person does not need to engage in overly strenuous activity to reap the benefits associated with hiking. An interesting effect that was noted was that occupationally active participants demonstrated a greater long-term benefit to perceived health than retired men. Perceived health is an important element of natural health, as is demonstrated by the widely known placebo effect. Individuals who feel

better tend to be more active and create a self-fulfilling prophecy with regards to health. These findings translate well into a North American context.

Urdampilleta, A., Gonzalez-Muniesa, P., Portillo, M. P., & Alfredo Martinez, J. (2012). Usefulness of combining intermittent hypoxia and physical exercise in the treatment of obesity. *Journal of Physiology and Biochemistry*, 68(2), 289-304. doi:10.1007/s13105-011-0115-1

This paper offers a discussion of current medical papers exploring the notion that intermittent hypoxia can be beneficial in the treatment of obesity and weight loss in general. There is a common observation in the weight loss literature that after a period of initial success in losing weight, obese patients typically reach a plateau. Beyond this, motivation is lost and weight is put back on. Urdampilleta and colleagues explain that, for various and complicated medical reasons, intermittent hypoxia can be useful in promoting higher basal noradrenaline levels and other metabolic changes that can aid in weight loss when combined with diet and exercise. Exercise under conditions of hypoxia improves insulin sensitivity and subsequently, helps the body make better use the nutrition it received. This work suggests that mountain hiking provides advantages to weight loss and overall health that are not present in other activities. It is a unique and effective opportunity to achieve fitness goals.

Wanner, M., Martin-Diener, E., Bauer, G. F., Stamm, H., & Martin, B. W. (2011). Allez hop, a nationwide programme for the promotion of physical activity in switzerland: What is the evidence for a population impact after one decade of implementation? *British Journal of Sports Medicine*, 45(15), 1202-1207. doi:10.1136/bjism.2009.070201

This paper outlines the effectiveness of a national physical activity promotion initiative undertaken in Switzerland. The Allez Hop program offered physical activity programs once a week over a 12-week period. The programs were built around walking and Nordic walking. Data from pretest and posttest surveys were analyzed to see if the program has a positive effect in promoting continued physical activity. Between 1997 and 2008 over 18,000 such programs were run across the country. At the time of the first follow-up survey, the proportion of people meeting the suggested physical activity requirements had significantly risen from 33% to 42%. By 2007, walking/hiking in the country had seen a dramatic rise in participation, up over 11 percentage points. Though this study does not speculate on the specific health benefits of hiking and walking, it offers an example of a successful initiative that encouraged individuals to become interested in physical activity. This paper is related to the discussion raised by Janssen (2012) regarding the costs of physical inactivity. Wanner et al. (2011) shows that by making physical activity more accessible to people, they can be encouraged to live healthier, more active lifestyles.