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The Physiological Effects of Walking Pilgrimage

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M. Brennan Harris presents in 'The Healthy Body' his kinesiological research conducted on the Camino de Santiago, examining the effects of walking pilgrimage on the self-identified experience of well-being in pilgrim bodies.

Key Words: pilgrimage, hiking, kinesiology, walking, Camino, Camino de Santiago, cardiovascular, musculoskeletal, metabolic, stress, injury, blisters, long-distance walking, journey pilgrimage .

Introduction

Although contemporary pilgrimage comes in many forms, a conventional definition involves a bodily journey to a holy or sacred destination. Indeed, the physical element was an integral part of early Christian pilgrimage, and many have compared the suffering of the pilgrim during the journey to the suffering of Christ.^[1] In other traditions the physical suffering may be seen as a form of bodily sacrifice or even a remembrance of the physical suffering of ancestors, as is the case with both the Hajj,^[2] and Native American pilgrimages such as the Trail of Tears.^[3] Many pilgrims and scholars have pointed to physical hardship or suffering as a catalyst for spiritual renewal. Bodily practices and gestures are theologically and practically important in both Eastern and Western religious traditions.

That bodily awareness informs the pilgrim's experience along the Camino has been suggested previously.^[4] Despite the connection between physical activity and psycho-spiritual well-being, few studies have focused on the physiology associated with these physical/spiritual practices. Some have examined walking as spiritual practice, acknowledging that the body plays a crucial role, but without reporting the

actual measured changes in physical exertion.^[5] In this article, I will explore the physical stresses and adaptations associated with walking pilgrimage as experienced primarily along the Camino de Santiago. There exist excellent reviews regarding the physiology of walking, such as *Walking to Health* by Jeremy Morris and Adrienne Hardman.^[6] In addition, many guidebooks for the Camino provide detailed descriptions of the topography of the route, and practical advice about the physical demands of the Camino. This article, however, focuses on describing the Camino in terms of the challenge it presents to the pilgrim body, the adaptation of the pilgrim body to that challenge, and how physiological challenges and adaptations may inform the Camino experience.

Technical Description of the Camino de Santiago

In order to understand the physiological stress of walking along the Camino de Santiago, it is necessary to describe the pilgrimage trail and the typical pilgrim in technical terms. First, the Camino de Santiago is a collection of routes that lead to the cathedral in Santiago de Compostela, north-west Spain, where, according to tradition, the remains of Saint James the Apostle are buried. Paths lead to Santiago from all directions: the north (*Camino Ingles* and the *Camino del Norte*), the south (*Camino Portuguese*), and the west (*Camino Finisterre*). The most commonly-walked route, however, is from the east; it is called the *Camino*

1. John Gordon Davies, *Pilgrimage Yesterday and Today: Why? Where? How?* (London: SCM, 1988).
2. Robin M. Taylor, 'Holy Movement and Holy Place: Christian Pilgrimage and the Hajj,' *Dialog* 50/3 (2011): 262-270.
3. Anton M. Pazos, ed., *Redefining Pilgrimage: New Perspectives on Historical and Contemporary Pilgrimages* (Burlington: Ashgate, 2014), 188.
4. Janneke Peelen, 'Bodily Learning: The Case of Pilgrimage by Foot to Santiago De Compostela,' *Cultural Styles of Knowledge Transmission: Essays in Honour of Ad Borsboom* (ed. Jean Kommers and Eric Venbrux; Amsterdam: Aksant Academic, 2008), 108.

5. Sean Slavin, 'Walking as Spiritual Practice: The Pilgrimage to Santiago De Compostela,' *Body & Society* 9/3 (September 01, 2003): 1-18.
6. Jeremy N. Morris and Adrienne E. Hardman, 'Walking to Health,' *Sports Medicine* 23/5 (1997): 306-332.

Frances and runs from the border between France and Spain to Santiago. Contemporary pilgrims typically begin at either Saint-Jean-Pied-de-Port on the French side or Roncesvalles on the Spanish side. The distance from these two points to Santiago is between 750 to 800 kilometres depending on the precise route taken. This represents a considerable journey by foot. The Pilgrim's Office in the cathedral at Santiago recognizes pilgrims who can document by way of a pilgrim's *credencial* (or passport) that they have walked at least 100 km, by providing a *compostela* or certificate. As a result, most individuals attempt to cover at least the 100 km distance. Furthermore, the statistics compiled by the Cathedral represent only those that have met this minimum distance requirement. In 2016, the Pilgrim's Office in Santiago reported that 277,854 pilgrims completed the Camino and received a *compostela*; 91.42 percent of those completed the journey on foot.^[7] Roughly one quarter of pilgrims (25.83 percent) reported their starting point as the town of Sarria, which represents the final 116 km of the *Camino Frances*. The next most commonly reported starting point (12.11 percent of pilgrims) is from Saint-Jean-Pied-de-Port. The balance of pilgrims start at other points on the *Camino Frances*, or walk other routes to Santiago (36.63 percent of pilgrims).^[8] On foot, these distances represent walking an average of 23 km per day, for from 5 to 33 days. The average Camino pilgrim walks every day. With the average walking speed of humans being approximately 5 km per hour,^[9] that means walking 4 to 5 hours per day. For reference, the typical distance walked by individuals in one day as part of their daily activity is approximately 8.3 km.^[10] Therefore, despite the relatively slow pace of most pilgrims, walking the Camino represents a significant (2.7 fold) increase in physical activity, and a considerable stress on the body.

Physiological Challenges of a Walking Pilgrimage

Cardiovascular Stress

Pilgrims along the Camino walk at many different speeds for a variety of reasons including the load carried, the terrain, and the pace of their companions. As such, one's companions tend to be those other pilgrims that are comfortable walking at the same pace; often, those walking with others walk at the pace of the slowest member of the group. Ultimately, it appears that despite all these variables, pilgrims adjust their speed to maintain a consistent relative intensity. In other words, they speed up or slow down based on how hard it feels. This is evidenced by one of our studies in which pilgrims wore heart rate monitors to evaluate the intensity of their walking. Individuals tended to walk at approximately 56 percent of their maximal intensity, which represents a relatively low stress on the cardiovascular system of the pilgrim's body.^[11] As such, most individuals possess the necessary cardiovascular fitness to walk the Camino, although some will walk it more slowly than others. In addition, because of the relatively low intensity and subsequently low stress on the cardiovascular system, pilgrims completing the Camino are likely to experience only modest improvements in cardiovascular fitness. To date there are only two published studies in the medical literature that have specifically measured changes in cardiovascular function among pilgrims on the Camino de Santiago.^[12] Our study showed modest improvements in cardiovascular fitness among a relatively young subject group participating in a 758-km traverse of the *Camino Frances*, whereas Remy Bemelmans et al. showed no improvement in vascular fitness among an older group of pilgrims walking 280 km over twelve days. There has also been a letter to the editor published in *Revista Espanola de Cardiologia* about a study which followed twenty-one low risk patients with cardiovascular disease along the Camino over six days.^[13] The authors

7. 'Informe estadístico Año 2016 Oficina del Peregrino,' accessed 27 August, 2018. <https://oficinadelperegrino.com/wp-content/uploads/2016/02/peregrinaciones2016.pdf>.
8. *Ibid.*
9. R. C. Browning et al., 'Effects of Obesity and Sex on the Energetic Cost and Preferred Speed of Walking,' *Journal of Applied Physiology* 100/2 (2006): 390-398.
10. David R. Bassett Jr. et al., 'Pedometer-Measured Physical Activity and Health Behaviors in U.S. Adults,' *Medicine & Science in Sports & Exercise* 42/10 (2010): 1819-1825.

11. M. Brennan Harris and Michelle R. Wolf, 'Cardiovascular Disease Risk Following a 758 km Pilgrimage,' *International Journal of Sports Medicine* 34/8, (2013): 727-731.
12. Remy H. H. Bemelmans et al., 'Vascular and Metabolic Effects of 12 Days Intensive Walking to Santiago De Compostela,' *Atherosclerosis* 212/2 (Oct, 2010): 621-627; Harris and Wolf, 'Cardiovascular Disease Risk Following a 758 km Pilgrimage,' 727-731.
13. Rafael Rubio and Valeriano Sosa, 'El Camino De Santiago in the Service of Cardiovascular Rehabilitation,' *Revista Espanola De Cardiologia* 61/4 (Apr, 2008): 435-436.

of this letter suggested that their findings indicated some improvement in cardiovascular fitness, although participants also completed a two-month walking program prior to the Camino.

The possible improvement in fitness is important to note as some studies suggest a correlation between physical fitness and self-reported psychological as well as spiritual well-being. The underlying mechanism for this relationship is based primarily on the physiological responses to exercise, including neural and hormonal adjustments such as increases in dopamine, serotonin, epinephrine, and norepinephrine. Additionally, there is a vast amount of literature on the euphoric effects of acute exercise, focusing primarily on release of endorphins.^[14] Furthermore, most of these changes are increased with increasing intensity of exertion, and do not occur if a specific threshold for intensity is not reached. Indeed, as evidenced by unpublished data from our study, individuals who began the Camino with a very high level of fitness actually experienced a drop in cardiovascular fitness during their pilgrimage, which was likely due to the lower exercise intensities they experienced compared to their normal exercise routines. Therefore, walking the Camino at low to moderate intensities is likely to elicit only modest improvements in cardiovascular fitness and the associated underlying physiological mechanisms, and these changes would therefore play a small role in altering the overall self-perception of the pilgrim's experience.

Metabolic Stress

While exercise intensity does not represent a significant challenge to most pilgrims on the Camino, the greatest physical stress in this form of walking pilgrimage is the overall volume of exercise experienced, due to the long duration and regularity of the activity. Advice from the American Pilgrims on the Camino, a confraternity dedicated to the route, states

daily distance on the Camino will depend on your personal desires and abilities but you must remember that to walk some distance, say 20 km, one day is one thing - to do it day after day for several weeks or a month is something else entirely.^[15]

This advice is consistent with our previous calculations indicating that the average pilgrim walks approximately four to five hours per day covering a distance of 23 km per day for anywhere from four to five days to 30 days or more, depending on the starting point and pace. Although it is possible to take days off from walking, most pilgrims along the Camino tend to walk some distance every day with at most one rest-day each week. This represents a significant physiological challenge, not in the form of cardiovascular stress, but rather as a high metabolic or energetic challenge as well as a constant, repetitive stress on the joints, ligaments, tendons, bones, muscles, and even the skin.

The metabolic challenge can be calculated from the estimated intensity based on earlier studies and the average time and distance covered by pilgrims during a typical pilgrimage along the Camino. The amount of energy it takes is also dependent on the size of the individual. However, based on these factors, it can be estimated that the average pilgrim nearly doubles his or her daily caloric expenditure during an average day of walking. In order to sustain this level of metabolic activity, it is necessary for pilgrims to greatly increase their daily caloric intake. How pilgrims accommodate this need for increased caloric intake varies. For some pilgrims, especially those travelling abroad, finding food can be a challenge due to culinary differences and language barriers, which may result in inadequate food intake. However, some pilgrims consider the pilgrimage a gastronomical journey^[16] as much as a spiritual one, and encounter no issues achieving adequate caloric intake.^[17] Indeed many pilgrims undertake the journey as part of a package tour, which ensures more than adequate access to food. Nevertheless, the two studies that have been published measuring the physiological effects of walking the Camino have reported significant decreases in body weight and body fat during either a twelve-day^[18] or thirty- to thirty-two-day pilgrimage,^[19] suggesting that the individuals in these studies experienced a caloric

14. Marni N. Silverman and Patricia A. Deuster, 'Biological Mechanisms Underlying the Role of Physical Fitness in Health and Resilience,' *Interface Focus* 4/5 (2014): 1-12.
15. 'American Pilgrims on the Camino: FAQs,' accessed 16 February 2015. <http://www.americanpilgrims.com/camino/faqs.html>.

16. Gemma Canoves and Raul Suhett de Morais, 'New Forms of Tourism in Spain: Wine, Gastronomic, and Rural Tourism,' *Tourism and Agriculture: New Geographies of Consumption, Production and Rural Restructuring* (ed. Rebecca Maria Torres and Janet Hemshall Momsen; London: Routledge, 2011), 205.
17. Canoves and de Morais, 'New Forms of Tourism in Spain,' 205.
18. Bemelmans et al., 'Vascular and Metabolic Effects of 12 Days Intensive Walking to Santiago De Compostela,' 621-627.
19. Harris and Wolf, 'Cardiovascular Disease Risk Following a 758 km Pilgrimage,' 727-731.

deficit. It is unclear how this negative energy balance ultimately affects the pilgrimage experience. Studies have clearly shown that the human brain is particularly susceptible to changes in energy balance.^[20] As a result, feelings of hunger may evoke a particular physiological and psychological response that deepens the perceived spiritual experience through enhanced interoception.^[21] Therefore, the feelings of hunger may demand from the pilgrim a greater awareness of the body and its inherent limitations.

Musculoskeletal Stress

Overload and adaptation

As stated above, perhaps the greatest stress to the pilgrim body during a walking pilgrimage is the constant, repetitive stress on the musculoskeletal and integumentary (skin) systems. Most people today are simply not used to walking for four to six hours a day, let alone doing so day after day. As a result, the walking pilgrimage significantly overloads these systems, eliciting a physiological response followed either by adaptation or injury. It is also important to note that the equipment and baggage pilgrims bring with them on their journey has a major influence on the stress that they undergo. It is readily apparent that the more weight a pilgrim carries with them, the more work the pilgrim will have to do. Indeed previous studies on individuals participating in long-distance hiking along the Appalachian Trail and Pacific Coast Trail show an increase in paresthesia, or numbness and tingling, in proportion to increasing pack weight.^[22] However, intensity can be adjusted by slowing down the pace. For pilgrims carrying their belongings with them, it is difficult to avoid the stress on the muscles and bones as they move the load from one destination to another. This is readily apparent to most pilgrims within the first day of walking. There are numerous reports of the many items left behind as pilgrims previously overburdened with stuff shed the unnecessary items. To that end many pilgrims wax philosophical on the meaning of leaving behind baggage; some suggest that that this is indeed one of

the reasons pilgrims embark on the journey in the first place. In any case, the pilgrim is confronted with his or her physiological limits and begins to lighten the load. This response is a behavioural modification adjusting to the physiological stress. Other strategies include buying more sophisticated backpacks to distribute the loads more evenly, or even using a cart or stroller to push or pull their possessions along. The weight of these possessions can sometimes be painful, and pilgrims undertaking the journey with little preparation will soon find that they become sore from carrying any unnecessary and/or unaccustomed load.

Continuing with a load that is too heavy may result in the development of pain and even injury. However, if appropriate adjustment is made, pilgrims will be able to continue on through the pain without injury. Over a period of days they will begin to adapt and experience an increase in musculoskeletal strength that allows them to carry their load much more easily. This improvement in muscular fitness may, in turn, elicit improved psychological factors as the pain begins to subside and the pilgrim begins to feel stronger. Alternatively, the individual may need to rely on other means of transporting packs. This may become a lesson learned by pilgrims about their physiological limits and indeed their humanness itself. While it may be possible to avoid this issue by shipping items or participating in a commercially-organized venture, ultimately the walking pilgrim must carry his or her body the minimum distance of 100 km to obtain their *compostela*.

Injury

Interestingly, it appears that participation in walking pilgrimage is more likely to result in injury rather than adaptation of the musculoskeletal and integumentary systems. Previous examinations of walking for fitness have suggested that no further improvements in muscle strength or joint flexibility are thereby gained.^[23] Perhaps this is due to the quotidian nature of walking as a daily activity. Preliminary data from our own studies even suggest that some individuals experience a decline in muscular strength, presumably due to the fact that in walking along the Camino, some pilgrims experience a less dynamic range of motion than during their regular daily routine (fewer stairs for instance). Instead, the many pilgrim accounts and numerous on-line guides indicate that the overload caused by the constant repetitive nature of walking pilgrimage results in injuries to the tendons, joints, and skin in the form of tendonitis, arthritis, and blisters. These types of

20. Ignacio Amigo and Alicia J. Kowaltowski, 'Dietary Restriction in Cerebral Bioenergetics and Redox State,' *Redox Biology* 2 (2014): 296-304.

21. A.D. (Bud) Craig, 'Interoception: The Sense of the Physiological Condition of the Body,' *Current Opinion in Neurobiology* 13/4 (2003): 500- 505.

22. L. Stewart Anderson et al., 'The Impact of Footwear and Packweight on Injury and Illness among Long-Distance Hikers,' *Wilderness & Environmental Medicine* 20/3 (2009): 250-256.; David R. Boulware, 'Backpacking-Induced Paresthesias,' *Wilderness & Environmental Medicine* 14/3 (2003): 161-166.

23. Morris and Hardman, *Walking to Health*, 306-332

injuries are the most likely reasons that pilgrims stop and either rest and recover, or end their journey. Although no published data exist to indicate how many pilgrims experience these types of injuries, 47 percent of a sample of 107 pilgrims who completed the Camino in the summer of 2014 reported at least one of these injuries.^[24]

Indeed, like the rates of injury reported in studies of long distance hikers,^[25] the rates of injury are probably under-reported in our survey, as only individuals who completed the pilgrimage completed the survey. Speculation on the popular website Caminoforums.com suggests that 20-30 percent of the pilgrims attempting the full *Camino Frances* do not complete the journey, due to some physical injury.^[26] Much space is taken up in various guidebooks and on internet forums on how to avoid walking-related injuries. Interestingly, some previous work looking at whether experience and conditioning in long distance hikers can reduce injury has not shown that these factors influence either the frequency or type of injuries.^[27] Indeed, our own unpublished data shows no correlation between the number of pilgrimages previously completed or experience in backpacking, and reports of injury.^[28] Based on the evidence cited above, it appears that the walking pilgrimage experienced by individuals along the Camino involving long-duration and high-frequency activity leads the typical pilgrim close to the physiological limits of their muscles, joints, tendons, and skin. Once again, by flirting with the limitations of their bodies and even experiencing pain or injury, pilgrims' awareness of their humanity increases, and this awareness likely impacts their emotional and spiritual experience.

Environmental Stress

Other factors to consider with regard to the physical challenges of walking pilgrimage are the environmental conditions that the pilgrim may encounter, including changes in temperature, altitude, and even increased exposure to sunlight. An individual's Camino trek may take place during any time of the year. Additionally, the weather is variable along the path. Heat and cold represent physiological stressors in and of themselves, and their effects may be exacerbated during exercise. Heat is generated during exercise by working muscles, and when the external temperatures are also high, this can result in increased stress on the body. The primary mechanism of thermoregulation by the human body is sweating and its resultant evaporative heat loss. Sweating without adequate fluid intake will result in physiological stress in the form of dehydration. Thus the pilgrim can experience significant fluctuations in body temperature and body water levels.

Hyperthermia

Examinations of the role of body temperature on endurance performance suggest that hyperthermia is one of the key limiting factors,^[29] although this seems to occur mainly to higher-intensity, competitive activities. Nevertheless, pilgrims walking the Camino during the summer can experience average daily temperatures as high as 35°C, depending on the route taken, and this, coupled with exercise, can represent a significant thermal load. Hyperthermia results in a decrease in muscular performance which is due, in part, to central nervous system fatigue as indicated by the individual's inability to voluntarily elicit a maximal muscular contraction.^[30] Hyperthermia also affects the brain and ultimately perception. Furthermore, unchecked hyperthermia in the form of heat stress and heat stroke can result in permanent neurological damage.^[31]

24. M. Brennan Harris and Taylor M. James, unpublished data; cf. Sang-cheon Choi et al., 'Injuries Associated with the 580 km University Student Grand Voluntary Road March: Focus on Foot Injuries,' *Journal of Korean Medical Science* 28/12 (2013): 1814-1821. The rates from our unpublished data are consistent with, if not lower than, this study reporting foot blisters in 95 percent of the 142 Korean college students participating in the University Student Grand Voluntary Road March, a route consisting of walking 580 km over 21 days with a small to medium pack.
25. Timothy B. Gardner and David R. Hill, 'Illness and Injury among Long-Distance Hikers on the Long Trail, Vermont,' *Wilderness & Environmental Medicine* 13/2 (6, 2002): 131-134.
26. 'How Many Who Set Out to Complete the Entire 800km Camino Frances do so? Camino De Santiago,' accessed 6 February 2015. <http://www.caminoforums.com/camino-frances/2986-how-many-who-set-out-complete-entire-800km-camino-frances-do-so.html>.
27. Gardner and Hill, 'Illness and Injury among Long-Distance Hikers on the Long Trail, Vermont,' 131-134.

28. M. Brennan Harris and Taylor M. James, unpublished data.
29. Michael J. Joyner and Edward F. Coyle, 'Endurance Exercise Performance: The Physiology of Champions,' *The Journal of Physiology* 586/1 (2008): 35-44.
30. L. Nybo and B. Nielsen, 'Hyperthermia and Central Fatigue during Prolonged Exercise in Humans,' *Journal of Applied Physiology (Bethesda, Md.: 1985)* 91/3 (Sep, 2001): 1055-1060.
31. Shoshana Burke and Menachem Hanani, 'The Actions of Hyperthermia on the Autonomic Nervous System: Central and Peripheral Mechanisms and Clinical Implications,' *Autonomic Neuroscience* 168/1 (2012): 4-13.

Although no studies have been published addressing the extent to which hyperthermia is experienced by pilgrims along the Camino, it is clear that exposure to such an environmental stressor may be yet another factor altering the overall perception and spiritual experience of the pilgrim. Recent reviews of the effects of hyperthermia and heat exposure on cognitive function using various measures of task complexity suggest that hyperthermia results in a decline in cognitive function.^[32] These reviews also indicate that more research is necessary to distinguish differences between passive (environmental) and active (exercise-induced) hyperthermia, as positive exercise-related side effects may blunt some of the cognitive impairment.^[33] Although the exposure to hyperthermia may represent a potential danger, it is important to note that the pilgrim will likely experience an adaptive response to repeated thermal stress, resulting in acclimation to hot environments. This acclimation typically results in improved thermoregulatory function through conservation of body water and improved sweating.^[34] However, there is little well-controlled research examining the effects of acclimation on cognitive function, and some studies show that indicators of improved cognitive function are task specific (i.e. the results depend on what type of cognitive function is measured).^[35] As a result, the pilgrim may handle the physiological stress of heat better as he or she adapts to the environment, and their overall perception of the experience may be positively or negatively impacted.

Hypothermia

Alternatively, cold weather can also heighten the physiological demand on the body, adding to the metabolic load due to increased muscular stiffness, shivering, and the dehydrating effect of breathing less humid air. Although fewer pilgrims walk the Camino during the winter months, it is possible to encounter severe cold weather at other times of the year,

particularly in the Pyrenees, where some pilgrims have lost their lives due to the weather conditions.^[36] It is more likely that pilgrims experience mild hypothermia by getting caught in the rain on a cool day without warm or waterproof clothing. Physiological changes that occur in individuals experiencing hypothermia can be severe and life-threatening, and even mild hypothermia elicits a significant stress response. Mild hypothermia occurs when core body temperatures drop approximately 2°C, and the symptoms can include shivering, increased blood pressure, amnesia, and poor judgement.^[37] This, in turn, could lead to further consequences. Clearly, walking pilgrimage, although innocuous-sounding at first, can place the pilgrim in unexpected environments that reveal the relatively narrow range of temperatures which the human body can tolerate.

Altitude

Another potential environmental stress that pilgrims along the Camino may encounter is the effects of altitude. Most of the Camino in Spain takes place at low altitude, but the first stage of the traditional *Camino Frances* from Saint-Jean-Pied-de-Port in France to Roncesvalles in Spain crosses several mountainous areas. Many consider this to be the most difficult section of the Camino. The highest point on this part of the route is the Col de Lepoder with an elevation of just over 1400 metres. In most texts of altitude physiology, this represents a relatively low level physiological challenge. At 1400 m, the standard barometric pressure drops to approximately 86 kPa (648 mmHg) compared to 101 kPa (760 mmHg) at sea level. This represents a 15 percent drop in the available oxygen.^[38] A drop in the atmospheric pressure results in a reduction in the loading of oxygen to haemoglobin in the blood, and ultimately a reduction in the amount of oxygen available to produce energy for physical activity. At these relatively low altitudes, a pilgrim may experience only about a 2 percent drop in arterial oxygen saturation levels from 98 percent at sea level to 96 percent. At rest, or at low to moderate levels of exertion, an individual is unlikely to experience any significant deleterious effects. However, performance at higher intensities can be impaired, and pilgrims are more likely to be working at these higher intensities as they ascend the mountainous terrain. The physiological response to working at these higher intensities with

32. N. Gaoua, 'Cognitive Function in Hot Environments: A Question of Methodology,' *Scandinavian Journal of Medicine & Science in Sports* 20/3 (2010): 60-70.; Peter A. Hancock, Jennifer M. Ross, and James L. Szalma, 'A Meta-Analysis of Performance Response Under Thermal Stressors,' *Human Factors* 49/5 (Oct. 2007): 851-877.
33. Gaoua, 'Cognitive Function in Hot Environments: A Question of Methodology,' 60-70.
34. Nigel A. Taylor, 'Human Heat Adaptation,' *Comprehensive Physiology* 4 (2014): 325-365.
35. Gaoua, 'Cognitive Function in Hot Environments: A Question of Methodology,' 60-70.
36. 'Camino De Santiago Climate and Conditions: the Road to Santiago,' accessed 20 February 2015. <http://www.theroadtosantiago.com/camino-climate-and-conditions.html>.

37. John W. Castellani et al., 'Prevention of Cold Injuries during Exercise,' 38/11 (Nov. 2006): 2012-2029.
38. 'Altitude.Org | Altitude Air Pressure Calculator,' accessed 26 February 2015. http://www.altitude.org/air_pressure.php

less oxygen available, results in increased breathing (hyperventilation), higher heart rates, and an increase in stress hormone levels, particularly norepinephrine. Thus, the pilgrim exercising at altitude may experience an increase in physical stress with elevated hormone levels, which may increase awareness, and even provide a sense of euphoria or greater well-being once the initial challenge is overcome.^[39]

Natural light

One final environmental factor to consider is exposure to natural light. While this may not have been uncommon for pre-modern pilgrims, the contemporary pilgrim is much less likely in their daily routine to have spent significant amounts of time outdoors. In a recent meta-analysis of studies using different cohorts of people, it was reported that the mean time spent outdoors on weekdays was 1.04 hours^[40] which would be significantly less time than the pilgrim experiences on a typical day. The increased time spent outdoors can be both harmful and beneficial. Once again, turning to the various Camino guidebooks, on-line advice, and to scientific studies, it is well documented that exposure to ultraviolet radiation can lead to skin damage, necessitating appropriate clothing choices and the use of sunscreen.

Recently, popular medical literature has begun to focus on the beneficial effects of sunlight exposure in the production of vitamin D, especially in light of the fact that nearly fifty percent of the world's population is at risk for vitamin D deficiency.^[41] Vitamin D is a major factor in determining health, playing an important role in preventing osteoporosis, some forms of cancer, autoimmune diseases, and cardiovascular disease. Therefore, increased exposure to sunlight may improve the health of a pilgrim through this mechanism. A second factor to consider as a result of increased sunlight exposure is psychological health. Several studies have shown that natural light improves seasonal

affective disorder and depression.^[42] Furthermore, pilgrims on the Camino de Santiago may also fall into a more regular pattern of light and dark exposure than they experience in urban and indoor light environments, in which exposure to light at night can disrupt circadian rhythms and result in depression and other mood disorders.^[43] The Camino lends itself to periods of daily physical activity followed by more quiet evenings due, in part, to fatigue and to the house rules in many of the *albergues* (pilgrim hostels with communal sleeping arrangements) that keep regular 'lights out' times. As a result, despite the potential ill effects of ultraviolet radiation, including sunburns, the increased time spent outside in natural light may improve the physical health and overall mood of the pilgrim, providing a greater sense of well-being.

Comment on the Highly Fit

For the strongest and fittest, walking pilgrimage may represent an activity that is considerably lower in intensity, frequency, and duration than normal activity. For instance, in some countries a postal worker who delivers mail on foot walks a considerable distance carrying a heavy load day in and day out. Other professions requiring similar activity can approximate the experience of walking pilgrimage, in which case pilgrimage itself offers no additional physiological challenge. The cardiovascular stress of walking a pilgrimage would not overload the system of a professional distance runner, for instance; if regular training is discontinued during the pilgrimage, then the runner would likely experience a decrease in fitness during the walk. For an individual who lifts weights or carries a heavy load on a regular basis, carrying only their necessities on a pilgrimage may likewise be easy and result in a negative adaptation. Such a decline in fitness may result in negative psychological and spiritual responses. Although a number of studies have been conducted examining the link between physical fitness, health and spiritual well-being, it is as yet unknown how these factors might influence a pilgrim's experience. Undeniably there are a multitude of ways these factors interact, and this is important to consider as each pilgrim has something to learn from facing physiological challenges whether negative or positive.

39. William P. Morgan, 'Affective Beneficence of Vigorous Physical Activity,' *Medicine & Science in Sports & Exercise* 17/1 (Feb. 1985): 94-100.

40. Brian L. Diffey, 'An Overview Analysis of the Time People Spend Outdoors,' *British Journal of Dermatology* 164/4 (2011): 848-854.

41. Michael F. Holick, 'Sunlight, Ultraviolet Radiation, Vitamin D, and Skin Cancer: How Much Sunlight do we Need?' *Advances in Experimental Medicine and Biology* 810 (2014): 1-16.

42. Alan L. Miller, 'Epidemiology, Etiology, and Natural Treatment of Seasonal Affective Disorder,' *Alternative Medicine Review: A Journal of Clinical Therapeutic* 10/1 (Mar. 2005): 5-13.

43. Tracy A. Bedrosian and Randall J. Nelson, 'Influence of the Modern Light Environment on Mood,' *Molecular Psychiatry* 18/7 (2013): 751-757.

Physical Training and Preparation

Given the challenges above and the information and advice available to today's pilgrim, many prepare physically, not realizing that their physical preparation may also prepare them for a spiritual journey. Training the body for pilgrimage is as simple as training for any physical activity and follows the basic rule of specificity. The rule of specificity principally states that the best way to prepare the body for a particular physical task is simply to perform that task. For example, the typical walking pilgrimage along the Camino de Santiago represents a low- to moderate-intensity walk, over a variety of terrains, lasting four to five hours per day for five to 30 days. Therefore, the best way to prepare for this walking pilgrimage is to do low- to moderate-intensity walking over a variety of terrain for four to five hours daily. In doing so, the individual has matched the mode, the intensity, and the duration of their pilgrimage journey. Therefore the pilgrimage represents a bodily challenge not unlike running a marathon as discussed in Janice Poltrick-Donato's article in this issue.

It is likely that not all pilgrims can or do train in a way that precisely mimics the actual walking pilgrimage. However, most pilgrims do not need to increase their cardiorespiratory fitness through higher-intensity training. As indicated earlier, the main physical issues that tend to cause injury and stop pilgrims on their journey are tendonitis and blisters. Therefore, the training should aspire to address these issues. Tendonitis or tendinopathy results from repetitive motion under heavier-than-normal loads, resulting in inflammation and degeneration of the tendons.^[44] Typically, tendonitis is due to a sudden increase in load, or due to a biomechanical aberration such as an abnormal gait or muscular imbalance.^[45] In order to address this issue the pilgrim must be aware of his or her body and its movements, so as to identify possible weaknesses. Once the problem area is identified, the pilgrim can address it with the help of a professional, or by strengthening the weak areas and gradually working up to heavier loads or longer distances.

The rule of specificity should also be applied to other aspects of training including: the equipment or gear that the pilgrim plans to bring along during the journey, dietary needs, and environmental challenges. As recommended in guidebooks for the Camino and in studies related to through-hiking as noted above,^[46] the beginning of the endeavour is not the best time to test out new equipment! In order to know whether footwear, backpacks, clothing, or other equipment might cause problems on the pilgrimage, the pilgrim should train with the same gear. This helps eliminate potential problems on the Camino. Furthermore, to the extent to which this is possible, in the interests of the walking body's nutritional needs, the pilgrim should research food options available along the Camino and make efforts to acclimatize beforehand. This may be especially true for pilgrims with special dietary needs such as vegans, or individuals with celiac disease.

Finally, the rule of specificity would suggest that training in the same environmental conditions as will be found on the pilgrimage would be optimal. Obviously, this may not be possible depending on where one lives and what time of year one plans to begin their pilgrimage. However, if time permits, the pilgrim may have the opportunity to train in weather conditions similar to those expected on the trail, and should take advantage of such opportunities. These would be ideal training days to test out specific clothing as well as potential hydration needs. For instance, simply by determining the difference in body weight before and after a training walk, while taking into account any water ingested during the training will give a good indication of an individual's sweat rate and hydration needs. By applying the criteria of specificity, pilgrims should thus be able to adequately prepare for the physiological challenges noted above.

Conclusion

In summary, the physiological challenges of a walking pilgrimage as represented by the Camino de Santiago, have a strong influence on the overall pilgrim experience. For some, the physical challenge represents a significant psychological barrier to overcome, while for others it does not. Indeed other long-distance hiking trails which one might use to compare to the Camino are arguably more strenuous due to terrain and lack of access to conveniences. While numerous guidebooks and tourism ventures suggest that anyone can walk the Camino, many of these same guides also include sections on common pitfalls: tendonitis, joint pain, blisters, dehydration, etc. Understanding the physiological mechanisms behind

44. Yinghua Xu and George A. C. Murrell, 'The Basic Science of Tendinopathy,' *Clinical Orthopaedics and Related Research* 466/7 (2008): 1528-1538.

45. Constantinos N. Maganaris et al., 'Biomechanics and Pathophysiology of Overuse Tendon Injuries,' *Sports Medicine* 34/14 (2004): 1005-1017.

46. Anderson et al., 'The Impact of Footwear and Packweight on Injury and Illness among Long-Distance Hikers,' 250-256.

these bodily challenges can help pilgrims prepare for a more rewarding journey, and also help them consider how overcoming these challenges may be part of discovering or rediscovering the physical nature of the human body.

Although this article has focused on the physical aspects of the Camino and their potential impact on the overall pilgrim experience, it would be incomplete without recognizing the likelihood that the relationship is a symbiotic one. It is not possible to separate the spiritual, psychological, and physical aspects of pilgrimage as the overall journey is experienced in the body. Indeed, numerous studies have investigated the effects of spiritual practices such as prayer and meditation on physiological parameters; a recent study by Julianne Holt-Lunstad *et al.* demonstrates that spiritual well-being is correlated with physical health.^[47] Therefore, the analysis of the physiological impact of walking pilgrimage simply confirms that the transformative journey occurs simultaneously with physical changes in the pilgrim's human body.

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47. Julianne Holt-Lunstad et al., 'Understanding the Connection between Spiritual Well-being and Physical Health: An Examination of Ambulatory Blood Pressure, Inflammation, Blood Lipids, and Fasting Glucose,' *Journal of Behavioral Medicine* 34/6 (2011): 477-488.

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