

ORIGINAL RESEARCH

Risk Determinants of Acute Mountain Sickness and Summit Success on a 6-Day Ascent of Mount Kilimanjaro (5895 m)

James S. Lawrence, BMedSci, BMBS; Stephen A. Reid, PhD

From the North Sydney Sports Medicine Centre, St. Leonards, Australia (Dr Lawrence); and the Sports Medicine Practice, Hobart, Australia (Dr Reid).

Objective.—The aims of this study were to assess incidence of acute mountain sickness (AMS) and summit success on a 6-day ascent profile of Mt. Kilimanjaro and evaluate potential risk factors for these outcomes.

Methods.—All trekkers through a single Australian tour company between August 2012 and July 2014 were included. Participants ascended via the Rongai route and attempted the summit on day 6. Daily assessments were made using the self-reported Lake Louise score (LLS) questionnaire. Two different AMS diagnostic criteria ($LLS \geq 3$ and $LLS \geq 5$) were used for data analysis. Risk factors for development of AMS and summit success were analyzed.

Results.—Over the 24-month period a total of 175 participants undertook the trek. Incidence of AMS was 52.6% ($LLS \geq 3$) and 22.9% ($LLS \geq 5$). Summit success was 88%. Age, sex, body mass index, and acetazolamide use were not associated with risk of AMS development. Age ≥ 40 years ($P = .0002$) and female sex ($P = .0004$) were both significantly associated with reduced summit success rate.

Conclusions.—Our cohort found a lower incidence of AMS and better summit success on a 6-day ascent of Mt Kilimanjaro than previously described in other groups on 4- and 5-day ascents. Female sex and age ≥ 40 years both predicted failure to summit, but did not increase risk of developing AMS. AMS is a common cause of morbidity on Mt. Kilimanjaro, and although the risk can be mitigated by a slower ascent, there is an ongoing need for education of individual trekkers, tour companies, and local authorities.

Key words: altitude sickness, mountain sickness, epidemiology

Introduction

Altitude illness commonly affects unacclimatized individuals traveling to altitudes over 2500 m. The term refers to a number of diagnoses including acute mountain sickness (AMS), which is most common, as well as the more severe high altitude cerebral edema (HACE) and high altitude pulmonary edema (HAPE).¹ AMS symptoms are nonspecific, with the diagnosis being defined as the presence of headache plus 1 or more of the following: gastrointestinal upset (anorexia, nausea, or vomiting), sleep disturbance, dizziness, and fatigue in an

individual recently arrived at altitude.² The risk factors consistently associated with the development of all forms of altitude illness are rate of ascent and absolute altitude reached.^{3,4} Other risk factors for AMS that have been variably identified include younger age, female sex, smoking, and obesity.^{5,6} A previous history of AMS was not found to significantly correlate with increased susceptibility in a recent meta-analysis.⁷ Acetazolamide use has been found to be protective against AMS and HAPE and is regarded as a common option for prophylaxis.^{8–10} When AMS symptoms are severe, descent is often required; if left untreated, AMS can progress to the life-threatening condition of HACE.^{11,12} HAPE can occur in combination with AMS/HACE, or in isolation.^{13,14} Both HACE and HAPE require urgent descent and treatment.

Increasing numbers of tourists are travelling to high altitude environments globally, thus being exposed to

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Corresponding author: James S. Lawrence, BMedSci, BMBS, North Sydney Sports Medicine Centre, 60 Pacific Highway, St Leonards, NSW 2010, Australia (e-mail: drjameslawrence@gmail.com).

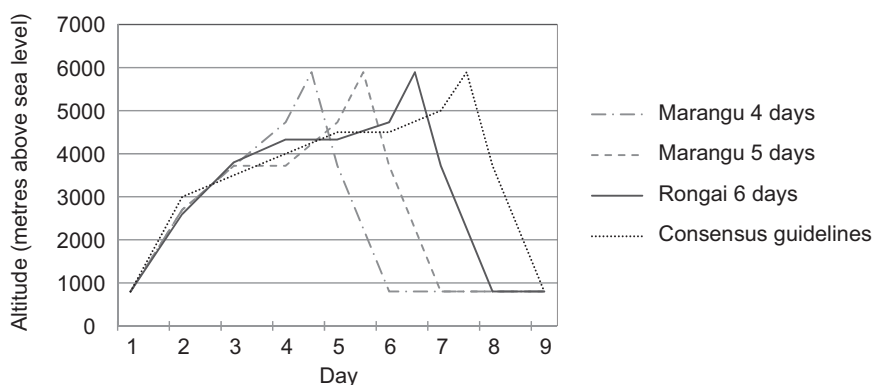


Figure 1. Diagrammatic representation of Mt. Kilimanjaro ascent profiles. The dotted line shows the minimum recommended ascent profile based on Wilderness Medical Society consensus guidelines.²³

potentially significant risks. Mount Kilimanjaro, at 5895 m, is the highest mountain in Africa and one of the “Seven Summits” (the highest mountains on each continent). It is easily accessible and the ascent is non-technical, making it a popular tourist trekking destination. As a result, up to 40,000 climbers visit the mountain each year, with the majority of those reported to attempt the summit.¹⁵ There are multiple routes up Mount Kilimanjaro, which vary in their speed of ascent. The most popular routes take between 4 and 7 days to ascend, although longer treks are possible. Descent is typically over 2 days. The Marangu (“Coca-Cola”) route has historically been the most popular ascent because it provides hut accommodation, rather than camping, and allows for the quickest climb, thus minimizing costs. On this route the summit is typically attempted on the fourth or fifth day. It is important to be aware of the variable terminology used when ascent profiles are described throughout the literature. For example, a 6-day route would be equivalent to a 4- or 5-day ascent, followed by a 1- or 2-day descent.¹⁶ The day on which the summit is attempted therefore most clearly defines the speed of the climb and will be used throughout this study.

The popularity and nontechnical nature of the Kilimanjaro trek belies the risks involved and the mountain tends to be underestimated.^{17,18} Previous studies describe very high rates of AMS on faster ascent profiles. Davies et al¹⁹ assessed trekkers on 4- and 5-day ascents, finding an overall AMS incidence of 77% (using Lake Louise score [LLS] ≥ 4) and summit success of 61%. There were no significant differences between 4- and 5-day ascents. Davies et al¹⁹ lost 100 of 281 participants to follow-up. Therefore, their results for AMS incidence and summit failure may in reality have been underestimated. Karinen et al²⁰ report a 75% incidence of AMS (LLS ≥ 3) in 112 trekkers during a 5-day ascent on the Marangu route. Only 51% of this cohort reached the

summit, defined as Gilman’s Point (the crater rim at 5681 m).

These climbing profiles have been criticized for their speed of ascent and associated high morbidity.²¹ Between 1996 and 2003, 25 tourist deaths were reported on Mt. Kilimanjaro, with 14 resulting from HAPE, HACE, or a combination.²² The Wilderness Medical Society consensus guidelines on AMS prevention recommend taking ≥ 2 days to reach 3000 m, followed by no more than a 500-m increase in sleeping altitude per day, with a rest day every 3 or 4 days.²³ The ascent profiles of different routes on Mt. Kilimanjaro are shown in Figure 1. Alternative routes with slower ascent profiles, taking 6 or 7 days to reach the summit, have been suggested as safer alternatives, although there are currently very few data to support this.²⁴ Nicol and Evans²⁵ recently found a daily prevalence of AMS of up to 40% in a cohort of 25 trekkers on a 6-day ascent via the Lemosho Glades route, although they do not quote an overall incidence of AMS for the trek. Mackie and Windsor²⁴ accompanied 12 trekkers on a 7-day ascent on the same route and report 91% reaching the summit with only 2 climbers experiencing AMS.

To date there have been no studies investigating the incidence of AMS in trekkers climbing the Rongai Route up Mt. Kilimanjaro, with the summit being attempted on day 6. The purpose of this study, therefore, was to investigate the occurrence of altitude illness and summit success among trekkers on this increasingly popular ascent profile. We hypothesized that the results would compare favorably with those for more rapid climbing profiles.

Methods

We conducted a prospective cohort study to assess the incidence of AMS and rate of summit success on a 6-day

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