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Correlates of Frailty among Aging Residents of Upper Selška Valley Villages under Ratitovec Mountain

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ABSTRACT

Frailty, multi-system dysregulation following multiple life stressors, is associated with age and vulnerability to negative health. Our model posits that variables such as age and sex affect biocultural changes resulting from lifestyle and alter frailty. We assessed frailty with a four-factor index. We expand understanding of frailty by examining associations with demographic, health, and lifestyle factors in a Slovenian sample. Between 2008 and 2009, 40 residents of the Selska Valley, Slovenia aged 55 to 85 years ($\overline{X}$=72, SD=7.24) participated in physical assessments, responded to the SF-36, and self-reported their own and family history of non-communicable diseases. Participants included 26 women (age 59–86) and 14 men (age 57–82). We used linear regression and t-tests to assess associations of these factors with frailty. Frailty was significantly positively associated with age, sex, length of residence in the village, and multiple self-reported health factors. Conversely, frailty was significantly negatively associated with height and showed a borderline significant association with diastolic blood pressure. Controlling for age and sex, significant associations remained between frailty and self-reports of health, along with painful and reduced activity levels. Frailty also interacts with lifestyle factors. Results suggest the model proposed by Walston and colleagues (2005) is a valid cross-cultural measure of frailty.

Key words: *biomarkers, elders, SF-36, physical activity, male-female differences*

Introduction

Frailty, multi-system dysregulation following responses to multiple life stressors, is associated with age and increases individual vulnerability to negative health effects[1–7]. As yet, researchers have not agreed on which body systems most indicate or impact frailty nor specific associated negative health outcomes[2,4,5]. Thus, multiple definitions of frailty typically are applied in clinical and field research[6–9]. Some aspects of frailty research, such as self-perceptions and reports, can be subjective as different individuals perceive their abilities based on their own sociocultural and behavioral expectations[5,7]. Self-reports of physical activity and health, as are included in this research, always are influenced by cultural, local and individual perceptions of what health should be[10]. Although different individuals may have the same level of functionality as others, they may view their functioning as below or above others with similar levels[7]. Quantitatively assessed frailty provides a specific, observable and measurable phenotype for analysis[2,11].

Given the broad array of physiological, environmental, and sociocultural factors that influence frailty and self-perceptions of health, a bioculturally-orientated research perspective such as promoted within biomedical anthropology and human biology is useful for disentangling somatic system alterations, cultural process and behavioral differences that result in individual frailty. Multiple subfields within biophysical and sociocultural anthropology converge upon health, somatic adaptations to stressors, and well-being over the human life span. Frailty represents a current assessment of somatic well-being following life-long responses to stressors across multiple physical and cognitive systems. Human population variation in response to life's stressors forms the basis of adaptive, sociocultural and behavioral responses to local ecological circumstances promoting variable individual biology and life spans. In addition, across multiple cultural settings

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aspects of social support, including for example presence of spouses, children, and kin, promote better health and less frailty in later life. Human adaptation and adaptability in face of life's stressors that maintain somatic stability have remained a major focus within biophysical anthropology since the international human biology programs of the 1960s and 70s. These programs set human biologists on the path to understand humankind's multiple bioculturally-based differences in response to local environments, from high altitude to arid and frigid environments, and through the changing environments of modern day that have developed secondary to population increase, industrial agriculture, and technological innovations of a monetized global industrial complex.

As with multiple chronic conditions, allostatic load, and general physiological dysregulation examined by biocultural anthropologists worldwide, frailty results from accumulating somatic losses, most likely secondary to lifelong exposures to stressors[5,4]. Numerous personal variables (e.g. age, sex, birthplace, education) likely affect and are in turn affected by endogenous sociocultural and lifestyle factors such as income, health and behaviors[5]. Exogenous and endogenous factors, along with individual and socioculturally-sanctioned coping mechanisms affect our responses to life's stressors, influencing every individual's stress level and physiological function[5]. They also interact over a lifetime to alter one's frailty and perception of their own health[5] making them of interest to anthropologists examining life history, sociocultural and genetic aspects of health and life span, and the evolutionary biology of growth, development and senescence.

Most people associate frailty with age and age-related loss of physiological function. In research samples, frailty often is associated significantly with age[2,12]. However, frailty is not determined directly by chronological age[5,7]. Rather, frailty is an age-related cycle of decline influenced by multiple social, cultural and physiological factors[2,3,5,7,13]. Put another way, frailty assesses biological age, which may differ from chronological age depending on how exogenous and endogenous factors interact[1,2,6,7]. The frailty cycle involves muscle loss (sarcopenia)[13] and reduced somatic activity[5], leading to additional muscle loss, continuing the frailty cycle[11].

An easily repeatable frailty index developed by Fried et al. and Walston on an USA sample provides an efficient method for assessing this cycle of decline[2,7]. This index allows researchers and clinicians to easily classify frail and non-frail individuals in field and clinical settings. Frailty indices reflect influences of disease and disability on declining somatic function and loss of physiological stability. The strength of this frailty index is its ease of use. It is based on only five biomarkers (walking speed, grip strength, physical exhaustion, low physical activity and recent unintended weight loss). Measures of walking speed, grip strength and physical exhaustion reflect muscle loss[2]. Low physical activity and unintended weight loss further reflect reduced somatic activity[2]. Regardless of specific factors promoting individual frailty, when assessed using these five biomarkers frailty predicts future loss of function and morbid and mortal outcomes, suggesting it is a robust assessment of the frailty phenotype[11].

Previous research in the USA employing the 5-factor frailty index reported significant associations of frailty and a variety of independent factors including education, age, sex, and prevalence of certain diseases[2,11]. Fried et al. assessed frailty in 5,317 people using these five biomarkers and followed them for 4–7 years. Therein the 5-factor frailty index predicted falls, decreased mobility, physiological declines and mortality over the next three years. Over three years, individuals exhibiting three of the five indexed biomarkers experienced more falls and showed decreased mobility, independent of age and other physiological ailments (Fried et al. 2001). Individuals displaying one or two biomarkers at baseline were at increased risk of full frailty (exhibiting three or more biomarkers) during follow-up[2].

Such frailty measures assess somatic function at a specific point in time and change as function improves or declines. However, this is not a problem. In research, this is a useful property. When combined with other physiological assessments, the dependence of frailty on measures such as allostatic load or influence on abilities to complete activities of daily living may be examined over time[2,11,14]. Biomarkers are the phenotypic expression of underlying physiological processes. Biological markers of aging are therefore expected to be predictive of physiological function. Biomarkers such as systolic and diastolic blood pressure and body habitus measures (skin folds, body mass index (BMI), and waist-to-hip ratio) assess secondary outcomes of dysregulated hormone cascades over time. These biomarkers, when tested in conjunction with frailty, add another layer of understanding to the underlying physiological mechanisms associated with frailty over time[14]. Individual frailty is significantly related to age, sex, education, income, self-reported physical disability and incidences of diseases such as arthritis, diabetes and congestive heart failure among elders in the United States[2]. Frailty also has been observed to interact significantly with blood pressure, disease prevalence, activity levels, and multiple other aspects of human variation[2,11,12].

Because of its nature, systematic somatic dysfunction, frailty likely reflects to some extent sociocultural setting and individual lifestyles, including marital status, occupation, education, and personal activity choices, in addition to poorer self-reported health, low physical activity and greater morbidity. Walston et al. suggest a need for studying poor physiological responses to stressors, for example systolic and diastolic blood pressure and waist-to-hip ratios, as these also affect frailty[7]. Fried, Walston and colleagues suggested that this five-factor index provides clinicians and researchers a tool useful worldwide for distinguishing frail from not-frail individuals[2,3,11]. However, research linking frailty to social factors, including age, sex, education, lifestyles and occupations and to future morbidity and mortality primarily have focused on North American samples[2]. Culturally-specific measures of frailty may not be accurate when applied to persons from other cultures or geographic settings. To understand frailty on a global scale, any proposed index and possible confounding factors must be examined across multiple populations. Novel and uncommon sociobiological factors, differential sociocultural interpretations, and biocultural interactions likely contribute differentially to elders' physiological function and perceptions of frailty across cultures.

In this paper, we examine frailty as a construct in a sample from a historically geographically remote area of Slovenia, the Selska Valley. The valley, surrounded by enclosing mountains and hills, remains rather remote, thus preventing large fluxes of migrants. Early settlement occurred after the 10th century when Slovene agrarian colonists entered the valley. Subsequently, during the 13th and 14th centuries, Frulian and then German colonists followed. Ever since, the Selska Valley has experienced little immigration[15–17]. Recently, Slovenia has experienced a 2.4% increase in individuals aged 65 and over (2001–2011) while the population aged 80 and over increased by 1.8% and the average age of the population increased from 38.9 to 47.2[16]. Also, out migration from these high mountain villages is approximately 2%, and from the valley villages is 8%, while migration between lowland villages is 10% and migration between small mountain villages is 23%. Still today there is little migration into or between villages and almost no migration into the valley[15]. Because of its historic isolation, low migration rates, and a pattern of patrilineal inheritance, the Selska Valley, particularly the upper valley under Ratitovec Mountain, has remained a fairly culturally homogeneous population into modern times[15,17,18].

Anthropology brings a fresh theoretical focus to frailty research as it combines a biocultural approach with the more common clinical and biomedical viewpoints of most previous research on frailty (see Crews 2005 and compare to Studenski et al. 2004)[1,9]. Frailty is a quantitative clinical phenotype[2,9,11]. Humans are dependent upon biocultural interactions to maintain their adaptedness in today's culturally constructed environmental settings. Biophysical anthropologists trained in the methods and techniques of modern human biology view modern human phenotypic variation through a biocultural and biosocial lens. Therefore, they explore not only genetic and physiological contributions to frailty, but also socially and culturally constructed and prescribed aspects of life that influence responses to stressors and vulnerability to detrimental somatic loses and health outcomes.

Applying frailty measures developed on US samples to residents of the Selska Valley may expose unexpected cultural confounders. In this more homogeneous sociocultural setting, we are fairly confident factors interacting to produce frailty will be physiologically based and influenced by sociocultural variability. The majority of our study participants have lived the majority of their lives in the Selska Valley, attended the same elementary school, practice the same religion and are employed in the same local industries and farming activities. They also share a similar culture more based in traditional seasonal and yearly patterns of activities than do their more urban-living peers and a similar history within the valley among themselves and their recent forbearers within the valley than peers outside the valley. This shared history and life ways lead to similar activity patterns, social interactions, and dietaries. As an example, in late-November and December (the time of our fieldwork) many households in the upper valley are self-sufficient farming families and may be observed dressing a fattened pig, brewing spirts such as brandy/slivovitz, making sour cabbage and turnips, and drying or preserving produce from their farms and gardens (personal observations). Senior members of this valley whom we sampled engage in similar daily activities and eat the same diet, experience the same life experiences, obtain their health care at the same local health center, and share the same sociocultural values, expectations, and traditions, suggesting that such factors will not greatly affect differences in frailty and health examined here.

Influences of life style and sociocultural differences are difficult to disentangle in more culturally and biologically variable samples, such as the USA, upon whom the frailty index originally was developed[2,11]. Before examining how culture influences frailty, it first is necessary to determine physiological influences. The Selska Valley of Slovenia provides a sufficiently different population from that within which the index was developed and will aid in testing its cross-cultural validity. This research adds to anthropological knowledge and extends understanding of late-life frailty by exploring a pervasive element of adult human variation in a cross-cultural context.

Our index of frailty follows that originally suggested by Walston (2005)[11]. Walston used five simple, noninvasive measures that are common manifestations defining a frailty phenotype. The index is now well-validated for distinguishing frail from non-frail individuals outside of a clinical setting[11]. It is therefore useful for anthropologists working in the field. One difference is our assessment of frailty lacks an indicator for unintended weight loss. However, for the remaining four biomarkers (walking speed, grip strength, physical exhaustion and low physical activity) we have measured data, along with extensive data on self-reported health, social activities, and physiological variation. We hypothesize that frailty will be associated significantly with biodemographic, physiological, and lifestyle factors: age, sex, education, marital status, occupation, blood pressure, body habitus, and self-reported activity and health, even in this rural Slovenian sample.

Our research extends previous studies of frailty to an Eastern European population allowing us to examine the validity of this simple frailty index in a novel setting. Included in this report are examinations of associations of frailty with a range of self-report and anthropometric data (Table 1)[7–9,11.] This study was designed to extend the demographic and cultural scope of frailty research to a segment of the Slovenian population by testing whether individuals classified as frail exhibit poorer self-reported health, lower education or more morbidity than those not so classified. This research contributes to our understanding of how frailty depends on lifestyles and how frailty influences health and physical activity[16].

In this study, marital status, years lived in the village, number of children, total number of cohabitants, and num-

TABLE 1
DEMOGRAPHIC AND PHYSIOLOGICAL FACTORS IN SELŠKA VALLEY SAMPLE (N=40) MEASURED IN 2008–09

Measure	Total Sample $\overline{X}$ (SD)	Men (N=14)		Women (N=26)		Difference (M-W) 95% CI
		$\overline{X}$ (SD)	Range	$\overline{X}$ (SD)	Range	
Age	72.9 (7.2)	71.0 (7.2)	57–82	73.8 (7.1)	59–86	–7.7–2.0
Years lived in village	62.1 (18.8)	59.7 (24.0)	9–82	63.4 (15.8)	37–86	–16.5–9.0
Height (m)	1.61 (0.09)	1.69 (0.05)	1.6–1.8	1.56 (0.07)	1.5–1.8	0.1–0.2
Weight (kg)	75.8 (16.8)	84.0 (18.1)	64–135	71.3 (14.6)	43–98	2.0–23.3
Blood pressure						
Systolic	139.4 (18.0)	138.2 (14.6)	121–167	140.0 (19.8)	97–184	–14.0–10.4
Diastolic	73.9 (11.9)	80.9 (14.3)	66–111	74.7 (10.0)	50–96	–1.7–13.9
Circumferences						
Waist (cm)	98.7 (11.9)	102.4 (13.7)	82–140	96.6 (10.5)	76–116	–2.3–13.7
Hip (cm)	108.5 (12.0)	105.1 (12.8)	91–142	110.4 (11.3)	90–136	–13.4–2.8
Upper arm (mm)	33.2 (14.0)	37.6 (20.6)	24–99	30.8 (8.2)	21–64	–2.6–16.2
Skinfolds						
Limb (mm)	33.2 (22.3)	24.7 (22.8)	12–100	38.5 (20.7)	11–81	–28.8–1.2
Trunk (mm)	50.9 (21.5)	43.0 (20.9)	17–89	55.5 (20.9)	15–10	–26.8–1.7
BMI	29.2 (5.6)	29.2 (5.7)	11–21	29.2 (5.7)	18–41	–3.8–3.8
Waist to Hip Ratio	0.91 (0.08)	0.98 (0.07)	0.86–1.1	0.87 (0.05)	0.77–0.9	0.06–0.14

Limb= Upper Arm plus Calf Skinfolds, Trunk = Suprailiac plus Subscapular Skinfolds

ber of cohabitants over 40 in the household are examined as proxies for social support. These forms of social support are associated with fewer somatic symptoms of aging, lower mortality rates and better self-perception of health in other samples, for example among elderly Kuwaitis[19]. In the Selska Valley population married individuals also have lower serum testosterone levels[17], possibly indicating lower stress levels. Years lived in a village also may reflect social support. Length of residence increases opportunities to form supportive alliances and relationships within a community. Number of children an individual has provides avenues for support for older individuals[19]. This model assumes the nature of one's parent-child relationships is positive because in most settings children provide social support to their parents. If the number of people in the home aged 40 or over indicates the number of individuals who help with activities of daily living, maintenance of the home and potentially contribute economically, these factors likely reflect social support as well[19]. Owning one's home is a socio-cultural variable, likely reflecting a social norm. Living in a family-owned home is typical in the Selska Valley, but owning one's home may increase exposures to stressors different from those of individuals who do not own their residence.

Self-reported occupation is assumed to represent each respondent's way of life for the majority of their life, a good possibility in this valley. Aside from being a sociodemographic variable, occupation also informs us of cultural norms. A person's occupation exposes them to various aspects of life and associated stressors. From the time individuals are at work and whether the job requires technical knowledge, to the people who they work with and whether they have to own transportation to get to work, all of these aspects make up part of an individual's sociocultural milieu. Residents of the Selska Valley generally work Monday-Friday in local industries such as electric motor manufacturing and a wood factory (e.g. wood products, furniture) or have occupations located in the economic capitol of the valley, Zelezniki17. There also are self-sufficient farmers, homemakers, lace makers and craftspeople residing within the valley. Education also may indicate cultural expectations of either staying in school or entering the workforce and honing technical skills. The years of education of most individuals may tell us about outside pressures and whether individuals with more school-based knowledge or more practical on-the-job training are considered more valuable to the community. Smoking cigarettes and the number of cigarettes smoked may also be a cultural construct in terms of what is acceptable behavior, peer pressure and local population values.

Background

Data reported here were obtained during an international collaboration between The Institute of Public Health of The Republic of Slovenia and The Ohio State University, Department of Anthropology. The major project goal is to examine health and wellness among residents of the Selska Valley, Slovenia[16]. Our sample consists of 40 residents of four small, historically geographically isolated villages located under Ratitovec Mountain. Today, roads transect the lower valley and the villages are less isolated. Some of the most isolated villages along the upper valley have been depopulated. For this research, participants were recruited mostly from villages in the upper valley to lessen possible variable external genetic and cultural influences16. They were recruited from areas wherein the original populations have resided over many generations in the valley.

By limiting cultural and genetic variation, some factors known to vary or interact with frailty may be excluded[2,11]. In a setting such as the Selska Valley where the culture and demographic backgrounds are relatively homogeneous, we are more likely to observe how frailty arises as phenotypic variation in physiological functioning than via sociocultural and genetic variability.

Valley residents tend to be engaged in local industry and occupations, including farming, and share access to the same healthcare, transportation and social systems[16,17]. The local population is relatively homogeneous, with respect to diet, environment, life ways and historical background, providing a novel research setting to explore frailty and variation in health. The frailty index we use was developed among North American community-dwelling populations, wherein individuals are from many different backgrounds and do not share cultural and biological variation[16,17]. The frailty index has not been examined in settings like the Selska Valley, where a geographic barrier limits external influences[15–17]. A focus on elders (persons aged 55 and older) fits this setting as the proportion of residents of the Selska Valley aged 65 and older increased 2.4% between 2001 and 2011[16]. Thus, the population at risk for frailty is increasing. The main goal of this research is to explore how frailty, assessed using a simple scale[11], is associated with biodemographic (age, sex, marital status, occupation, and education), physiological (blood pressure, BMI, and skinfolds), and behavioral (activity, pain in activity) variation among those aged 55 years and older residing in the Selska Valley.

Materials and Methods

Data for this study were obtained during fieldwork in 2008 and 2009[16]. Cross-sectional sampling was opportunistic, but based upon Vidovic and colleagues' previous work and knowledge of household demographics in the valley[20,21]. During visits to the Selska Valley in 2008 and 2009, data were obtained from 40 participants aged 55 years and older who had participated in previous research with Vidovic. Of those contacted only one man declined to participate in the study. Of the forty participants, 26 were women (ages 59–86) and 14 men (ages 57–82). Although this small sample may potentially bias statistical analyses, it does provide sufficient information for a preliminary analysis of frailty in this Eastern European setting.

Data collection

Data were measured and recorded and questionnaires administered by a three-person field team during both field seasons. All anthropometric measurements were completed by the same researcher (DEC). Questionnaires, consent forms and instructions to participants were presented in Slovenian by a native speaker (MV). All verbal responses and results of measurements were recorded by either DEC and MV or a trained field assistant. IRB approval was obtained from Slovenian commission for medical ethics. All participants signed informed consent forms.

Self-report data

A self-report questionnaire was used to elicit information on age, sex, years lived in the village, years of education, marital status, and life-long occupation. In addition, information on personal and family medical history, lifestyle, including use of tobacco and alcohol, patterns of exercise, self-reported daily strenuous and social activities, and health using the SF-36 health survey was obtained[22]. Written in English, the questionnaire was translated to Slovenian by a native speaker (MV). Participants responded mainly in Slovenian.

Physical assessments

All but one participant (suffering from congestive heart failure) completed a walk of fifty feet on a flat interior surface. A stop-watch was used to time each walk (walking speed). Hand grip strength and physical exhaustion were assessed using a handheld dynamometer (Model: 5030J1 S/N: 30209342). Individuals gripped the dynamometer to their maximum possible grip strength and then held at least minimal pressure for 30 seconds or until they were too exhausted to continue (strength and exhaustion). Those failing to hold any pressure for 30 seconds were recorded as physically exhausted.

A GPM® Anthropometer was used to measure each participant's standing height twice following Lohman et al.[23], values were recorded to the nearest millimeter. Weight was measured to the nearest kilogram using a Health-O-Meter® portable scale. Systolic and diastolic blood pressures were measured three times while participants were seated using a Baumanometer® and a Littman® stethoscope (DEC).

Most anthropometric measurements were completed while participants were wearing light clothing. Waist and hip circumference were measured twice using a non-stretch fiberglass tape marked in centimeters (cm) and millimeters (mm) while participants were standing. Upper arm circumference, reported in mm, was measured twice. Skinfold measurements were taken at the triceps, calf, subscapular and suprailiac locations as specified by Lohman et al. on the skin or with light coverings using a Lange® Skinfold Caliper. Pulse rate was counted for thirty seconds at the ulnar artery[23].

Body Mass Index (BMI), determined as weight (kg) divided by height (m)-squared, and waist-hip ratio, waist circumference divided by hip circumference, were examined for possible differential associations with frailty. Trunk (hip plus subscapular skinfolds) versus limb (triceps plus calf skinfolds) fat deposits also was examined for association with frailty. For all repeated measures, the average of measurements was used in analyses.

Constructed Variables

Self-reported presence (0 = not present, 1 = present) of heart attack, stroke, diabetes, arthritis, and congestive heart failure were summed to create a morbidity score for each participant. Education was condensed such that participants with only an elementary school education are scored 1, those with some middle school or high school 2, those with any education above high school as 3.

Frailty

Our frailty index closely follows Walston's[11] five-factor frailty index. It includes walking speed, grip strength, physical exhaustion and low physical activity. Median values were determined for walking speed, grip strength and physical activity. Participants with measurements above median value for walking speed were assigned a 1, as it is assumed that more frail individuals will walk more slowly and therefore take more time to walk 50 feet. Participants at or below the median were assigned a 0. Participants with measurements above median value for grip strength were scored 0. Measurements at or below the median received a 1, as it assumed that more frail individuals will be less able to apply grip pressure on the dynamometer and have a lower grip strength than less frail individuals. Physical exhaustion was recorded when participants could not retain any pressure on the dynamometer for thirty seconds. Those who became physically exhausted were scored 1, those who did not 0. Individuals who become physically exhausted while performing such tasks are assumed to be more frail than individuals who do not become physically exhausted. Low physical activity is assessed as a combination of nine self-reported aspects of daily activity from the SF-36 Health Survey[22] (i.e. vigorous activity, moderate activity, lifting or carrying groceries, climbing several flights of stairs, climbing one flight of stairs, bending or stooping, walking more than a mile, walking several blocks, walking one block). Participants ranked their activity as impaired (1), moderately impaired (2), or not impaired (3). Scores for each participant were summed across categories to assign each a frailty score ranging from 9 to 27. Scores were recoded as 0 for low or no limits (23 or above, N=28) and 1 for moderate to high limits (22 or below, N=12) for activity. It is assumed that less frail individuals will have fewer limitations on their physical activity than will more frail individuals. Given the small sample size, physical activity was divided by upper one-third and lower two-thirds, rather than quartiles. Scores on the 4 frailty assessments were summed per individual. Possible scores were 0 (no frailty) to 4 (high frailty). Participants were divided for further analysis into approximately the frailest third and the least frail two-thirds of the sample. Participants with scores of 3 or 4 on the frailty index were assigned 1 (moderate to high frailty; N=12). Participants with scores of 0, 1 or 2 were assigned 0 (no or low frailty; N=28). All analyses were run with frailty as a scale (0–4) and as a dichotomous variable (0 or 1).

A social support index was created using marital status, number of children, number of people in the home and number of people over 40 in the home. This index was not significantly associated with frailty as either a scaled or dichotomous variable (data not reported).

Statistical analyses

Data were analyzed using SPSS® 20 statistical software. Frailty is expected to be dependent on exogenous or constitutional factors, age and sex, as well as endogenous ones, such as education, social support, marital status, number of children, occupation. Regression is an appropriate statistical approach for examining frailty as either a nominal or continuous variable. Data analyses included determining bivariate associations of frailty with all categorical and quantitative variables and self-report of health. Reported are standardized coefficients, along with standard errors and associated p-values. Next, all associations are evaluated while controlling for possible effects of age and sex using multivariate linear regression. Finally, stepwise regression is used to estimate which demographic, physiological and self-reported factors are associated independently with frailty. Our available sample size of 40 participants is sufficient for estimating bivariate statistical associations of all study variables with frailty and for examining these associations while controlling for age or sex. However, it is rather small for estimating multivariate models of frailty.

Results

Descriptive statistics

Average age of the sample is 72.9 years (SD=7.2), women are slightly older than men (73.9 and 71.0, respectively, p=0.241; Table 1). In the full sample, the average frailty score was 1.60 (SD=1.3). Women's frailty score averaged 2.12 (range 0–4) and is significantly higher than observed in men (0.64, 0–4, $p \leq 0.0005$). The average amount of time lived in the village was 62.1 years (SD=18.8) and did not differ significantly between men and women. In addition to frailty, height and weight differed significantly between men and women (Table 1). Men are 0.13 cm taller and 4.5 kg heavier than are women, but both men and women share the same average BMI (29.2 kg/m^2). However, men and women differ significantly in their w/h, with men posting 0.98 and women 0.87, indicating greater storage of fat by women in their hips (Table 1). No significant or large differences in blood pressure, body circumferences, or skinfolds are observed between men and women (Table 1).

Bivariate analysis of frailty (0–4) with demographic, physiological and self-reported data

We predicted frailty would be significantly associated with variation in demographic and physiological measures. Significant positive associations are observed be-

TABLE 2
ASSOCIATIONS OF BIODEMOGRAPHIC AND PHYSIOLOGICAL FACTORS WITH FRAILTY (0–4) IN SELŠKA VALLEY SAMPLE (N=40)

Physiological variable	β	SE	p-value	R^2
Age	0.084	1.183	0.003	0.213
Sex	1.473	1.122	<0.0005	0.292
Height (m)	–7.230	1.172	0.002	0.228
Weight (kg)	0–0.016	1.306	0.211	0.041
Blood pressure				
Systolic	0–0.004	1.331	0.717	0.003
Diastolic	0–0.034	1.268	0.052	0.096
Circumferences				
Waist (cm)	–0.001	1.328	0.957	0.000
Hip (cm)	0.010	1.322	0.573	0.009
Upper arm (mm)	–0.024	1.288	0.120	0.064
Skinfolds				
Limb (mm)	0.015	1.272	0.126	0.068
Trunk (mm)	0.009	1.314	0.387	0.021
BMI	0.004	1.496	0.926	0.015
Waist to Hip ratio	–2.959	1.308	0.307	0.029

SE: Standard error of the estimate; β: Standardized regression coefficient; Frailty assessed as 0 (none), 1 (low), 2 (moderate), 3 (intermediate), 4 (high)

TABLE 3
SOCIODEMOGRAPHIC FACTORS AND FRAILTY (0–4) IN SELŠKA VALLEY SAMPLE (N=40)

Social variable	β	SE	p-value	R^2
Marital status	0.654	1.311	0.162	0.054
Years lived in village	0.022	1.263	0.044	0.103
Number of children	0.002	1.334	0.988	0.000
Occupation	–0.242	1.313	0.273	0.031
Education	–0.525	1.307	0.214	0.040
Own home	0.002	1.334	0.977	0.000
Number of cohabitants	–0.026	1.333	0.803	0.002
Number of cohabitants over 40	0.162	1.305	0.204	0.042
Smoked 100 cigarettes or more over lifetime	0.457	1.325	0.475	0.014

SE: Standard Error of the Estimate; β: Standardized regression coefficient; Frailty assessed as 0 (none), 1 (low), 2 (moderate), 3 (intermediate), 4 (high); Marital Status: 0 = married, 1 = unmarried (never married, divorced, widowed)

tween frailty and age (p=0.003) and between frailty and being female (p≤0.0005) (Table 2). A significant negative association is observed between frailty and height (p=0.002), as well as between frailty and diastolic blood pressure (p=0.05) (Table 2). Higher frailty also is associated positively with years of residence in the valley (p=0.04) (Table 3). This association may be confounded with participant age and is examined later in multivariate models controlling for age and sex. No other aspect of biodemography, life style or social support is related significantly to frailty.

Frailty and perceived health

We also expected frailty to be associated with participants' perceptions of their own health and with their daily activities (Table 4). Frailty is positively associated with self-reports of poorer overall health (p=0.01) and lack of energy (p=0.004). Frailty also is associated with participants' expectation that their health will decline with increasing age (p=0.02) and greater disagreement with the statement »My health is excellent« (p=0.03). A borderline association between frailty and greater tiredness (p=0.07) also is observed (Table 4).

TABLE 4
FRAILTY (0–4) AND SELF-REPORTED HEALTH IN SELŠKA VALLEY SAMPLE (N=40), 2008–2009

Self-reports of health	β	SE	p-value	R^2
Overall health	0.281	0.861	0.011	0.159
Disease prevalence	0.044	1.407	0.797	0.002
Activity limited by health	0.219	1.713	0.300	0.028
Bodily pain past week	0.254	1.240	0.100	0.070
Pain interferes with daily life	0.217	0.977	0.081	0.080
Have energy	0.500	1.327	0.004	0.202
Felt tired	–0.287	1.257	0.068	0.085
Tendency towards sickness	–0.172	1.314	0.290	0.029
Healthy for age	0.269	1.798	0.226	0.038
Health expected to decline	–0.494	1.659	0.019	0.136
Disagrees that health is excellent	0.544	1.965	0.028	0.120

SE: Standard Error of the Estimate, β: Standardized regression coefficient, Frailty assessed as 0 (none), 1 (low), 2 (moderate), 3 (intermediate), 4 (high)

Bivariate analyses of frailty (0.1) with demographic, physiological and self-reported data

As a dichotomous measure, frailty is significantly associated with sex (p=0.002), height (p<0.005), marital status (p=0.022), lack of energy (p=0.001), and participants' expectation that their health will decline with increasing age (p=0.008; Table 5). Borderline significant associations also are observed between frailty and weight (p=0.07) and

TABLE 5
BIVARIATE ASSOCIATIONS OF SOCIODEMOGRAPHIC AND PHYSIOLOGICAL FACTORS WITH FRAILTY (0,1) AND FRAILTY WITH SELF-REPORTED HEALTH IN SELŠKA VALLEY SAMPLE (N=40), 2008–2009

Physiological variable	β	SE	p-value	R^2
Sex	0.462	0.412	0.002	0.231
Height	–3.060	0.385	<0.005	0.328
Weight	–0.008	0.450	0.069	0.085
Marital status	0.353	0.438	0.022	0.130
Number of cohabitants over 40	0.085	0.447	0.054	0.094
Lack energy	1.536	1.297	0.001	0.236
Health expected to decline	1.571	1.625	0.008	0.171

SE: Standard Error of the Estimate, β: Standardized regression coefficient, Frailty assessed as 0 (none, low, or moderate; N=28) and 1 (intermediate to high; N=12)

number of household cohabitants aged 40 years and older (p=0.05; Table 5). But, neither age nor length of time residing in the valley associate WITH significantly frailty when examined as a dichotomous assessment.

Multivariate analyses controlling for age and sex

Multivariate analyses controlling for age and sex are presented in the text, but not tables. As described earlier (Table 1), in this sample frailty as a continuous measure is higher at older ages (p=0.003) and among women (p≤0.0005). Therefore, we used linear regression controlling for age and sex to explore independent associations of all independent variables with frailty as a continuous variable (0–4). Significant associations continued to be observed between frailty and systolic blood pressure (p=0.029), self-reported poor overall health (p=0.038), interference of pain with daily life (p=0.024), lack of energy (p=0.029), and disagreement with the statement that self-perceived of the participant is excellent (p=0.012) when controlling for age and sex. None of the available biodemographic variables, including length of time living in the valley, remained significant predictors of frailty after controlling for the effects of age and sex on frailty.

Exploring independent associations with frailty as a dichotomous measure while controlling for age (p= 0.001) and sex (p=0.003), height (p=0.001) and systolic blood pressure (p=0.015) are significantly and independently associated. In addition, lack of energy (p=0.011) remained significantly associated with frailty after sex (p=0.003) and age (p= 0.001) were controlled. In a final stepwise model, including all variables previously shown to be significantly associated with frailty (0.1), the best fitting model for predicting frail/non-frail in this Slovenian sample includes age (p=0.018), sex (p=0.003) and lack of energy (p=0.027).

Discussion

Frailty is a biologically and physiologically complex phenotype partly dependent upon one's sociocultural and environmental settings[2,13]. Given this complexity, frailty must be carefully studied across populations and geographic settings to understand how it develops, what influences its degree, and different trajectories of frailty across cultural and ecological settings[11]. Such research endeavors fall within the realm of biophysical anthropology, specifically the bioculturally-orientated research of human biology. In our sample, the exogenous variables sex and age significantly predicted frailty. Frailty was higher at older ages and women showed greater frailty than men. Height is associated significantly, but negatively with frailty, and frailty is higher for those who have lived more years in the valley. These results may be linked to social and cultural factors that affected elders living in this area of Slovenia over their life spans[16]. However, those who have lived in these villages the longest also are the oldest and length of time was not statistically significant in models including age. In this sample, 19 shorter-term residents lived in these villages less than 69 years, while 21 long-term residents have lived in the valley for 69 years or more. Mean ages of longer and shorter term residents are 76.0 and 69.4. When controlling for age and sex, neither height nor length of residence in the village are significantly associated with frailty. As expected, results support the association of frailty with self-reports of poor health and lack of energy even when controlling for age and sex. It is not likely that social factors are influencing these results as any such effects should be attenuated by similar social circumstances and control for age and sex. When frailty was examined as a dichotomous variable in stepwise regression, age, sex and self-reported lack of energy were significant independent predictors. Lack of energy likely is a component of the frailty phenotype as it likely reflects to some degree muscle loss and should be investigated further in follow-up research. Notably, marital status is not significantly associated with frailty, which may speak to the nature of marriage in this isolated Slovenian setting. Elsewhere, a living spouse is associated with better self-reports of health, lower physiological risk factors (e.g.: blood pressure, glycemia) compared to older adults without a spouse[19]. Why no significant association is observed between marital status and frailty in this sample is not clear. One suggestion is that at advanced age single people in the valley may face the same daily activities and health challenges as the married and they also share the same health care and social system, making the presence of a spouse a less influential aspect of overall physical frailty, although having a spouse may still influence disease risk and social support, issues not examined in this report.

As observed in this Slovenian sample, reports from elsewhere indicate women have higher frailty than men. For example, Fried et al.[2] reported frailty was two times higher among women in a US sample, and higher in every 5-year age group examined than among men. Similarly, Etman et al.[12] reported women were more affected by frailty than men across 11 European countries (not including Slovenia).

Fried et al.[2] proposed that women may start with less lean body mass and muscle strength than men of the same age and therefore cross their frailty threshold sooner in life. Without data on recent weight loss, we are not able to determine if differential weight loss influenced differences in frailty between women and men in this study.

Etman et al.[12] and Fried et al.[2] both examined associations of frailty with self-reports of health. Neither observed a significant association between them. Fried et al.[2] did report higher frailty associated significantly with presence of two or more diseases in a North American, community-dwelling sample. Self-reported energy and activity levels also were associated significantly with frailty in Fried et al.'s study[2]. Therein, 72% of frail individuals reported difficulty in mobility and 60% reported difficulty in performing instrumental activities of daily living, including activities that allow social independence such as grocery shopping and performing housework. Fried et al. hypothesized two pathways to frailty, through age-related processes unrelated to disease and through disease processes[2]. A contributing factor may be that self-perceptions of health vary across cultures. If so, research into cross-cultural patterns of frailty utilizing self-reports of health may reflect to some extent local sociocultural constructs of health along with aspects of biophysical health. Finally, no previous report of an association between height and frailty could be found after an extensive literature research. One possibility is that shorter height may reflect poor growth during one's youth. In this sample, adult height may be a proxy for poor nutrition or other stressors experienced early in life.

Results reported here are based on a study with several limitations. The small sample limits the range of phenotypic variation included, potentially biasing estimated averages and associations. However, many of these observed associations appear to be of sufficient significance to warrant additional attention. Also our index is limited to 4 of 5 proposed frailty biomarkers[11]. Still, we have robust measures of strength, endurance, walking speed and physical activity. Our assessment of physical activity is particularly robust as it relies on 9 different questions from the SF36, a widely used and validated questionnaire for assessing self-reported activity and health[22]. Another potential limitation is verbal miscommunication due to translation of questions from English to Slovenian. However, because all questions were translated and explained to participants in Slovenian by a native speaker who has worked with this population for several decades on numerous research projects, we are confident that this is not the case. Another possibility is that participants may have felt compelled to respond with answers they believed would meet researcher's expectations. We have no way to assess this possibility. Given such possible limitations, this research applies an existing frailty model[2] to a sample from a novel population to explore its applicability across cultures[7].

Frailty is not a stable phenotype; it is constantly changing. Frailty is a process, improving or declining over time[12]. Components of frailty may change in different directions[2]. Testing and classifying individuals as frail is not the goal of these studies. Understanding how frailty develops, leads to morbidity, and exploring ways to diminish individual frailty and bolster ones' vitality are the goals[2,3,7]. This report begins to detail correlates of frailty in a Slovenian sample, but does not explore how frailty influences later outcomes such as mortality and life span. These analyses will require follow-up of this sample and additional participants in the future. Additional research also will address the cross-cultural validity of our current assessment of frailty. Another question is whether frailty is a single phenotype composed of specific somatic alterations, or if there are multiple frailty phenotypes secondary to multiple underlying causes[11]. As research focuses on a comprehensive understanding of factors underlying frailty, clinicians may have opportunities to intervene early on its precursors. Understanding differential vulnerability to various stressors, developing specific combinations of processes for promoting less rapid frailty, and pharmacological and therapeutic modulators of stress responses, somatic damage, and sarcopenia are possible clinical avenues for slowing acquisition of the frail phenotype. Most importantly, continued exploration of frailty will allow us to determine additional covariates and how frailty is related to mortality and survival in the Selska Valley.

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POVEZANOST RANJIVOSTI MEĐU STARIJIM STANOVNICIMA GORNJE SELŠKE DOLINE PODNO RATITOVCA

S A Ž E T A K

Ranjivost, višesistemska deregulacija uslijed višestrukih životnih stresora, povezana je s dobi i osjetljivsti na negativno zdravlje. Naš model ističe da varijable kao što su dob i spol utječu na biokulturalne promjene koje proizlaze iz načina života i mijenjaju ranjivost. Ispitivali smo indeks ranjivosti s četiri faktora. Proširili smo razumijevanje ranjivosti uvidom u povezanosti s demografskim i zdravsvenim čimbenicima te stilom života u slovenskom uzorku. Između 2008. i 2009. godine, 40 stanovnika Selške doline, Slovenija, u dobi od 55 do 85 godina (X=72, SD=7,24) sudjelovalo je u fizičkom procjenama, odgovorilo je na upitnik SF-36, i izvjestilo o svojoj i obiteljskoj povijesti nezaraznih bolesti. Među sudionicima uključeno je 26 žena (dob 59–86) i 14 muškaraca (dob 57–82). Koristili smo linearnu regresiju i t-test za procjenu povezanosti tih čimbenika s ranjivosti. Ranjivost je značajno pozitivno povezana s dobi, spolom, duljinom boravka u selu i s povećanjem broja prijavljenih zdravstvenih čimbenika. Suprotno predviđenom, ranjivost je značajno negativno povezana s visinom i pokazala je granično značajnu povezanost s dijastoličkim krvnim tlakom. Kontroliranjem za dob i spol, značajna povezanost je ostala između ranjivosti i prijavljenog zdravlja, zajedno sa bolnim i smanjenim razinama aktivnosti. Ranjivost ima interakciju s čimbenicima stila života. Rezultati ukazuju kako je model, kojeg su predložili Walston i suradnici (2005.) valjana transverzalna mjera ranjivosti.