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## **Quantifying insufficient coping behavior under chronic stress: a cross-cultural study of 1,303 students from Italy, Spain and Argentina**

Delfino, Juan P; Barragán, Elena; Botella, Cristina; Braun, Silke; Bridler, René; Camussi, Elisabetta; Chafrat, Verónica; Lott, Petra; Mohr, Christine; Moragrega, Inés; Papagno, Costanza; Sanchez, Susana; Seifritz, Erich; Soler, Carla; Stassen, Hans H

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# Quantifying Insufficient Coping Behavior under Chronic Stress: A Cross-Cultural Study of 1,303 Students from Italy, Spain and Argentina

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## Key Words

Chronic stress · Insufficient coping skills · Affective disorders · Early detection · Students

## Abstract

The question of how to quantify insufficient coping behavior under chronic stress is of major clinical relevance. In fact, chronic stress increasingly dominates modern work conditions and can affect nearly every system of the human body, as suggested by physical, cognitive, affective and behavioral symptoms. Since freshmen students experience constantly high levels of stress due to tight schedules and frequent examinations, we carried out a 3-center study of 1,303 students from Italy, Spain and Argentina in order to develop socioculturally independent means for quantifying coping behavior. The data analysis relied on 2 self-report questionnaires: the Coping Strategies Inventory (COPE) for the assessment of coping behavior and the Zurich Health Questionnaire which assesses consumption behavior and general health dimensions. A neural network approach was used to determine the

structural properties inherent in the COPE instrument. Our analyses revealed 2 highly stable, socioculturally independent scales that reflected basic coping behavior in terms of the personality traits activity-passivity and defeatism-resilience. This replicated previous results based on Swiss and US-American data. The percentage of students exhibiting insufficient coping behavior was very similar across the study sites (11.5–18.0%). Given their stability and validity, the newly developed scales enable the quantification of basic coping behavior in a cost-efficient and reliable way, thus clearing the way for the early detection of subjects with insufficient coping skills under chronic stress who may be at risk of physical or mental health problems.

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## Background

Today, noncommunicable diseases (NCDs), such as depression, hypertension, type 2 diabetes mellitus, asthma or rheumatoid arthritis, have reached epidemic propor-

tions with enormous socioeconomic impact [1, 2]. Most of the NCDs are interrelated to each other as indicated by the high comorbidity rates between psychiatric and somatic conditions [3]. Although the etiopathogenesis of NCDs is largely unknown, a number of exogenous factors have been identified as triggering the development of these diseases: unhealthy diet, overweight, extensive consumption behavior, insufficient physical activity and insufficient coping behavior under chronic stress [1, 4–6].

NCDs and vulnerability to mental health problems are as prevalent among college and university students as in the general population [7]. Since 75% of subjects with major psychiatric disorders have their onset in the age range of 17–24 years [8], most campuses offer programs to help students with mental health issues and to educate academic staff with respect to the early detection of students at risk of psychiatric problems [9]. In fact, students encounter significant levels of chronic stress over quite a long time, which can aggravate preexisting psychiatric conditions or trigger the development of new mental health problems or other NCDs [10–15]. Academic and nonacademic stresses include competition in classroom, tight schedules, frequent examinations, moving away from home, adaptation to new social environment, financial issues or transition to a new developmental stage.

Survey data show that 19% of students experience high or very high levels of distress and 83% elevated levels of distress, compared to only 3% of the general population [16, 17]. This latter finding is of particular clinical relevance as chronic stress can raise blood pressure [18], increase the risk of heart attack and stroke [19, 20], suppress the immune system [21] and increase the risk of developing psychiatric disorders such as anxiety [6], depression [4] or schizophrenia [5]. Moreover, insufficient coping behavior under chronic stress has been linked to higher rates of (1) depressive symptoms among subjects of the general population, (2) relapse among patients under treatment for clinical depression and (3) negative symptoms among subjects with an elevated vulnerability to psychosis and schizophrenia [22–26].

In addition to health problems, insufficient coping behavior under chronic stress can significantly affect the academic performance of students. It can lead to elevated alcohol consumption and/or the use of illegal drugs or cause premature withdrawal from college/university prior to the completion of education [27–29]. As most academic advisers and lecturers are not trained as psychological counselors, Mohr et al. [30] attempted to develop standardized means for the early identification of freshman students with insufficient coping skills under chronic

stress and at risk for mental health problems. Such standardized means could be used routinely so that students identified in this way might benefit from early interventions. In their normative study of 1,217 students from 3 different sites in the US and Switzerland, coping behavior was quantified by 2 self-report questionnaires: the 28-item Coping Strategies Inventory (COPE) (dispositional version) was used to assess basic coping behavior and the 63-item Zurich Health Questionnaire (ZHQ) served as external validation criterion. The authors found 2 highly stable and reproducible scales that reflected socioculturally independent personality traits in terms of activity-passivity and defeatism-resilience. The external validation data revealed a close relationship between high scores on the defeatism scale and impaired physical and mental health.

Given the great practical relevance of these findings in view of the early detection of freshman students at risk of physical and mental health problems, our study aimed to replicate and potentially refine the results of Mohr et al. [30] through 3 independent, socioculturally diverse samples of university students from Italy, Spain and Argentina. Specifically, we addressed the following issues: (1) the extent to which the structural properties of the COPE instrument as derived from Swiss and US-American data can be replicated through data from Italy, Spain and Argentina; (2) the extent to which the structures are influenced by sociocultural differences between the study sites, and (3) the extent to which the percentage of students with insufficient coping behavior under chronic stress differ between study sites.

## Methods

Following the same methodological approach as described in Mohr et al. [30], our study was comprised of (1) a learning sample of 419 university students from Italy (Milan); (2) a second learning sample of 400 university students from Spain (Castellón), and (3) a test sample of 484 university students from Argentina (Cipolletti). According to power analyses conducted by Mohr et al. [30], the sample sizes of 400 subjects per center were regarded as covering 90% of the expected empirical variance in coping behavior (1,500 subjects for 95%). The 3 study sites in Europe and South America were chosen in such a way that the issue of sociocultural differences of clinical relevance could be investigated. As to the recruitment procedures: a classroom approach was used in Argentina where all students of a classroom were informed about the principal goals of our project and invited to participate in the study. This approach simulated a so-called census, a survey that measures the entire target population. By contrast, in Italy and Spain we used a random sampling approach where study administrators sought to enroll 400 students in central, highly frequented campus areas. In this approach, the survey relied on a ran-

**Table 1.** Composition of the 3 study samples with respect to gender and age (mean ± standard deviation)

	Total	Males	Females	Age, years
Italy (Milan)	419	212	207	21.8±2.1
Spain (Castellón)	400	202	198	20.9±2.3
Argentina (Cipolletti)	484	132	352	19.9±2.1

domly selected sample of subjects from the target population. The 2 different approaches were chosen in order to look for potential selection biases caused by students with mental health problems (such students were deemed to be less likely to voluntarily enroll in the study). All students filled out the 28-item COPE [31] (dispositional version in which respondents report the extent to which they usually do the things listed when they are stressed: I usually do not do this at all; a little bit; a medium amount; a lot; available in the standardized form for 6 languages on <http://www.bli.uzh.ch/Left07b.php>) and the 63-item ZHQ which assesses the factors regular exercise, consumption behavior, impaired physical health, psychosomatic disturbances and impaired mental health [32] (available in standardized form for 6 languages from the above website).

The ZHQ health survey is primarily used for epidemiological questions and as an instrument for the selection of a healthy control population. It quantitatively assesses consumption behavior (alcohol, smoking, medications, illegal drugs; how much do you usually drink per week? How much do you usually smoke per day? How often have you taken the following medications within the last 3 months? How often have you taken illegal drugs within the last 3 months?); impaired physical health (Have you ever suffered from one of the following disorders or diseases?); physical activities (How often do you go for a walk/hike? How often do you ride a bike? How often do you play a sport?); psychosomatic disturbances (Have you suffered from one of the following disorders within the last 6 months?) and impaired mental health (Have you ever suffered from one of the following symptoms? Have you ever undergone psychiatric or psychological treatment? Has a member of your family committed suicide?). The items are summed up within the prespecified categories to yield severity scores.

The COPE assesses the strategies by which an individual aims to cope with the demands of everyday life and to balance the responsibilities at school, work and home. As these demands can produce a chronic state of tension (chronic stress), the COPE instrument provides valuable clues about the extent to which these demands may (1) exceed personal and social resources due to insufficient coping skills and (2) lead to symptoms such as insomnia, difficulties to concentrate, increased difficulties with decision-making, excessive feelings of tiredness and exhaustion, increased worry, depressed mood, social withdrawal, physical inactivity and somatic symptoms such as stomach aches, raised blood pressure and high blood glucose levels.

The structural properties of the COPE instrument were determined by means of a neural network (NN) analysis [33] (multilayer perceptron NN approach connecting the neurons of input and output layers via one or more hidden layers in such a way that

the final NN model optimally predicts the coping behavior scores for all subjects under investigation from their item scores [30]). In particular, we searched for the optimum number of dimensions that were reproducible across study sites, while explaining a maximum of the observed between-subject variance. The function *crit* with the free parameters *N* (number of dimensions/scales) and *N<sub>k</sub>* (number of items that make up the *k*-th scale; *k* = 1, 2, *N*) served as a criterion for the iterative optimization that simultaneously optimized within- and between-scale association (absolute values):

$$crit = crit \left[ N > 1; N_k > 1, k = 1, 2, \dots, N; \sum_k N_k = N_{items} \right]$$

$$\sum_{k=1, N} \sum_{\substack{i, j \in Wk \\ i \neq j}} r(xi, xj) = max \quad \text{Maximization: within-scale} \quad (1)$$

$$\sum_{k=1, N-1} \sum_{\substack{l=k+1, N \\ j \in Wl}} r(xi, xj) = min \quad \text{Minimization: between-scale,} \quad (2)$$

where *r(xi, xj)* denotes the absolute value of association between the *i*-th and the *j*-th item and *Wk* the set of items that make up the *k*-th scale.

Upon completion of each optimization step, results derived from the learning sample were verified through the replication sample, so that overadaptation to the local properties of each single sample was avoided. As this algorithm does not distinguish between local and global maxima, a random-walk strategy was applied using 10,000 random permutations as start configurations for the optimization. All scales were orthogonalized by standard Gauss transformation, normalized (zero means, standard deviations of 10) and validated by computing the correlation between the resulting scales on the one hand and the ZHQ factors regular exercises, consumption behavior, impaired physical health, psychosomatic disturbances and impaired mental health on the other. We estimated empirical variances by systematically evaluating all possible  $n(n-1)/2$  euclidean distances between the *n* subjects' 28-dimensional feature vectors (the optimal resolution of subtle between-subject differences in coping behavior is the ultimate goal of our optimization).

Statistical analyses were carried out by means of the Statistical Analysis Software SAS/STAT 9.3 (PROC FREQ, MEANS, CORR and TTEST), while a proprietary program developed in our Institute was used for the NN analysis (<http://www.ifrg.uzh.ch/gen08.php>).

The project was approved by the Ethics Committee of the Canton of Zurich and the local ethics committees in Italy, Spain and Argentina.

## Results

Our recruitment procedure yielded roughly identical numbers of male and female students in Italy and Spain, whereas in Argentina female students were 3 times more likely to enroll in the study than their male fellow students (table 1). However, we will see later that gender plays a minor role, if at all, when addressing the question

**Table 2.** Cross-cultural differences

General health factor	Spain (n = 400)	Italy (n = 419)	Argentina (n = 484)	p value
Regular tobacco consumption	2.4±5.04	2.2±3.74	1.2±3.06	<0.0001
Regular alcohol consumption	6.2±6.16	6.9±5.96	2.5±3.52	<0.0001
Regular use of medicines	3.5±4.34	2.3±3.52	3.7±3.74	n.s.
Illegal drugs	1.5±4.12	1.0±2.61	0.5±1.63	<0.001
Impaired physical health	5.7±10.4	7.8±9.25	10.4±11.7	<0.0001
Psychosomatic disturbances	3.9±2.43	3.9±2.74	4.9±2.75	<0.0001
Impaired mental health	1.8±1.92	2.1±2.19	3.8±2.07	<0.0001
Regular exercise	10.5±5.51	9.3±4.83	9.3±8.16	n.s.

Separate analysis of the ZHQ factors tobacco and alcohol consumption, illegal drugs, impaired physical health, psychosomatic disturbances and impaired mental health revealed highly significant differences ( $p < 0.001$ ) between Spain and Italy on the one hand and Argentina on the other. No such differences were found for the comparison between Spain and Italy. n.s. = Not significant.

of quantifying insufficient coping behavior under chronic stress.

Separate analyses of the ZHQ factors regular tobacco consumption, regular alcohol consumption, regular use of medicines, illegal drugs, impaired physical health, psychosomatic disturbances, impaired mental health and regular exercise yielded highly significant differences in consumption behavior and general health between Italy and Spain on the one hand and Argentina on the other (table 2). All this indicates that sociocultural factors are relevant in this context, the more so as gender differences in the Argentinean sample in terms of the ZHQ scales impaired physical health, psychosomatic disturbances, impaired mental health and regular exercises exceeded those observed with the Italian and Spanish samples by far. Specifically, female Argentinean students appeared to be sicker than their male fellow students in terms of impaired physical health and psychosomatic disturbances, whereas no such differences were found with respect to impaired mental health (table 3).

Next, we used the NN search algorithm in order to determine the structural properties of the COPE instrument. It is the specific strength of our study design that we could rely in this context on independent learning and test samples so that testing on the training data was avoided. Interestingly, the optimization algorithm yielded the same 2-dimensional solution with 17 and 11 items that was found in the previous analysis of data from Switzerland and the US (table 4). Optimizations run separately for males and females did not reveal structural differences despite the highly significant gender differences in general health.

**Table 3.** Gender differences among Argentinean students

ZHQ scale	Males (n = 132)	Females (n = 352)	p value
Impaired physical health	7.9±12.0	11.4±11.4	<0.0001
Psychosomatic disturbances	3.6±2.14	5.3±2.81	<0.0001
Impaired mental health	3.5±1.99	3.9±2.10	n.s.
Regular exercise	13.8±7.57	7.6±7.73	<0.0001

The gender differences are all given as means ± standard deviation.

The 2 COPE scales assess basic coping behavior in terms of activity (activity-passivity) and defeatism (defeatism-resilience). Activity is best described through items like turning to work, getting help and advice from other people or coming up with a strategy, whereas defeatism is characterized by behavior like giving up, using alcohol, or refusing to believe that this has happened. Passivity is understood as negative scoring on the activity scale and resilience as negative scoring on the defeatism scale. The term resilience is used here as a broader concept, encompassing all those endogenous mechanisms that support and maintain health, thereby enabling patients to cope with stressful situations. This particularly includes personality traits supporting or impeding social skills [34, 35]. These 2 dimensions described >65% of the observed interindividual variation inherent in the 28 COPE items (>43% by activity, >22% by defeatism).

**Table 4.** COPE: activity and defeatism

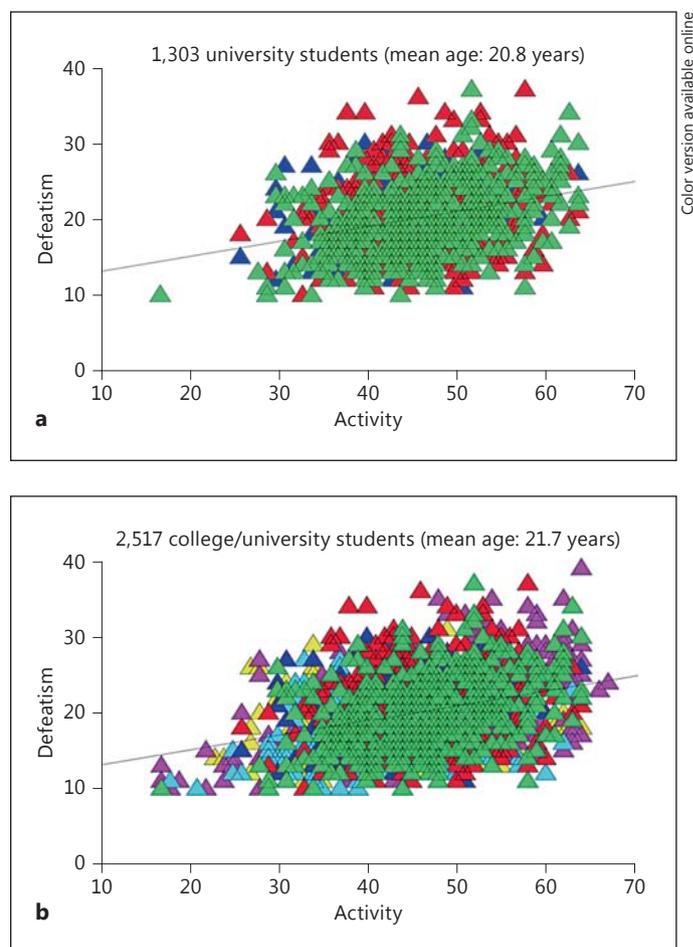
*Items underlying the new COPE scale 'activity'*

- 1 I've been turning to work or other activities to take my mind off things.
- 2 I've been concentrating my efforts on doing something about the situation I'm in.
- 5 I've been getting emotional support from others.
- 7 I've been taking action to try to make the situation better.
- 9 I've been saying things to let my unpleasant feelings escape.
- 10 I've been getting help and advice from other people.
- 12 I've been trying to see it in a different light, to make it seem more positive.
- 14 I've been trying to come up with a strategy about what to do.
- 15 I've been getting comfort and understanding from someone.
- 17 I've been looking for something good in what is happening.
- 18 I've been making jokes about it.
- 20 I've been accepting the reality of the fact that it has happened.
- 21 I've been expressing my negative feelings.
- 23 I've been trying to get advice or help from other people about what to do.
- 24 I've been learning to live with it.
- 25 I've been thinking hard about what steps to take.
- 28 I've been making fun of the situation.

*Items underlying the new COPE scale 'defeatism'*

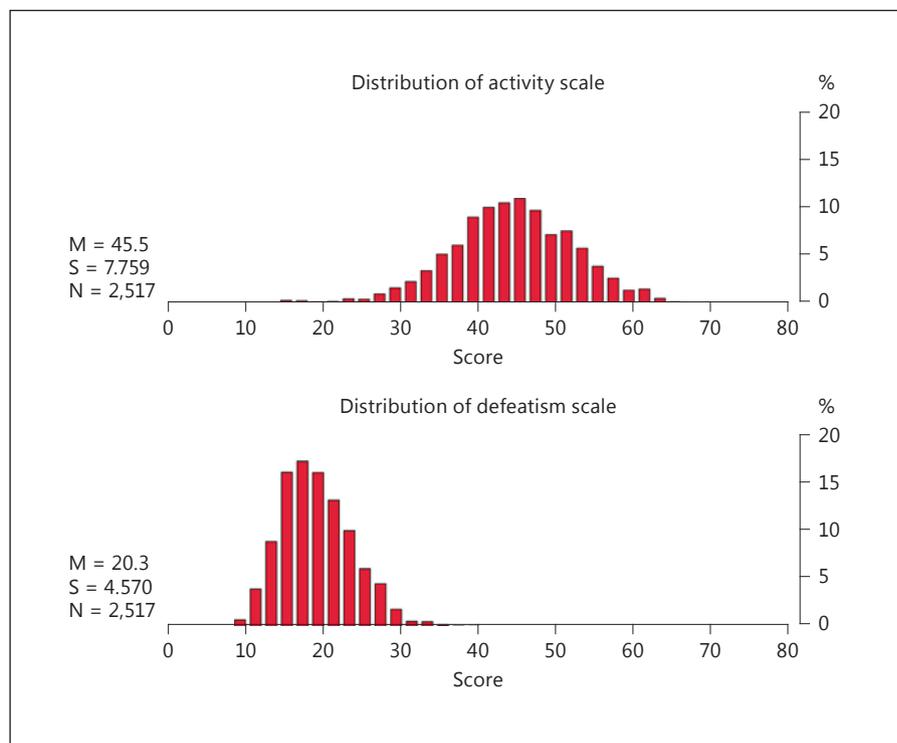
- 3 I've been saying to myself 'this isn't real'.
- 4 I've been using alcohol or other drugs to make myself feel better.
- 6 I've been giving up trying to deal with it.
- 8 I've been refusing to believe that it has happened.
- 11 I've been using alcohol or other drugs to help me get through it.
- 13 I've been criticizing myself.
- 16 I've been giving up the attempt to cope.
- 19 I've been doing something to think about it less, such as going to movies, watching TV, reading, daydreaming, sleeping or shopping.
- 22 I've been trying to find comfort in my religion or spiritual beliefs.
- 26 I've been blaming myself for things that happened.
- 27 I've been praying or meditating.

As the global maximum of our optimization was detected by a random-walk algorithm, the item-scale correlations  $r_{is}$  necessarily reflect the optimally achievable configuration for the given samples of 1,303 college students. In detail, we found  $r_{is} = 0.506 \pm 0.074$  for the activity-passivity scale, while the correlation between activity-passivity items and defeatism-resilience scale was  $0.000 \pm 0.076$ . By contrast, we found a slightly reduced  $r_{is} = 0.463 \pm 0.063$  for the defeatism-resilience scale along with a nonzero correlation of  $0.154 \pm 0.087$  between defeatism-resilience items and activity-passivity scale. The nonzero correlation was



**Fig. 1.** Coping behavior under chronic stress in Italy, Spain and Argentina (a) compared to 6-center study from Switzerland and the U.S. (b). Scatter plots of the raw scores activity (x-axis) versus defeatism (y-axis) as derived from the COPE data of 419 university students from Italy (blue), 400 university students from Spain (red) and 484 university students from Argentina (green) in comparison to 1,214 students from Switzerland (Zurich: German speaking/light blue; Lausanne: French speaking/yellow) and the US (purple). Colors refer to the online version only.

caused by the somewhat reduced discriminatory power of items 19, 22, 26 and 27 of both the Italian and the Spanish COPE version. These 4 items assess the role of religious and spiritual aspects when attempting to cope with difficult situations. The ambivalence (positive and negative feelings) inherent in our data could either indicate language problems (item difficulty) or a socioculturally diverse relationship to religious and spiritual values: a subgroup of test persons regard religion and spirituality as a positive coping mechanism, whereas another subgroup (the majority) see all this as a sign of defeatism (giving up).



**Fig. 2.** Coping behavior under chronic stress, 6-center study from the Psychiatric University Hospital Zurich ( $n = 2,517$ ). The distributions of the raw activity (a) and defeatism (b) scores are approximately normal and give no indication of multimodality (no between-center differences) despite major differences in consumption behavior and general health. M = Mean; S = standard deviation; N = number of students.

The above data demonstrate clear support for the chosen 2-dimensional solution: (1) high within-scale consistencies, (2) no cross talk between activity items and defeatism scale ( $r_c = 0.000 \pm 0.076$ ) and (3) a modest cross talk between defeatism items and activity scale ( $r_c = 0.154 \pm 0.087$ ). That is, activity items are completely unrelated to defeatism scores, while 4 items contributing to defeatism scores tend to also increase activity scores (in a subset of test persons).

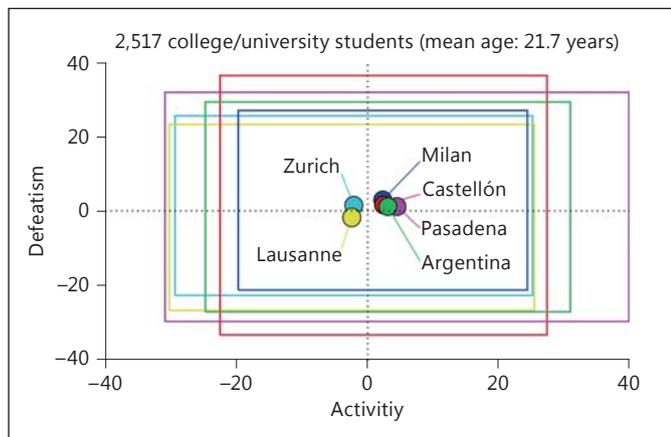
Scatter plots of the raw scores activity (x-axis) versus defeatism (y-axis) showed considerable interindividual variation (fig. 1a) with scores covering ranges of 10–70 (activity) and 10–40 (defeatism) very similarly across study sites. Virtually no scatter plot differences between the 419 university students from Italy, the 400 university students from Spain and the 484 university students from Argentina were found.

Once the structural properties of the data from Italy, Spain and Argentina were determined and the corresponding normative data computed, we were able to make direct comparisons with the results derived through the previous data from the German-speaking part of Switzerland (Zurich;  $n = 406$ ), the French-speaking part of Switzerland (Lausanne;  $n = 404$ ) and the US (Pasadena;  $n = 407$ ) [data courtesy of Mohr et al. 30]. These com-

parisons yielded only minor differences between the 6 centers in Italy, Spain, Argentina, Switzerland and the US, such as the finding that the US-American students showed a somewhat broader range of variation on the activity scale (fig. 1b).

Additionally, we looked at the distributions of the raw activity and defeatism scores as derived from the combined samples in order to detect deviations from normality, for example in terms of multimodality caused by systematic between-center differences. The unimodal, approximately normal distributions for both scales gave no indication of systematic shifts between the centers (fig. 2).

For practical purposes, the raw activity and defeatism scales were standardized for zero means along with standard deviations of 10 and orthogonalized by standard Gauss transformation in order to eliminate the correlation of 0.250 between the raw scales. Figure 3 shows the mean scores and variation of the scales activity (x-axis) versus defeatism (y-axis) as derived from the normalized orthogonal COPE data of 419 students from Italy (Milan), 400 students from Spain (Castellón) and 484 students from Argentina in comparison to 407 students from the US (Pasadena), 406 students from the German-speaking part of Switzerland (Zurich) and 401 students from the French-speaking part of Switzerland



Color version available online

**Fig. 3.** Coping behavior under chronic stress, 6-center study from the Psychiatric University Hospital Zurich. Mean scores and variation of scales activity (x-axis) versus defeatism (y-axis) as derived from the COPE data of 419 students from Italy (Milan), 400 students from Spain (Castellón), 407 students from the US (Pasadena), 484 students from Argentina (Cipolletti), 406 students from the German-speaking part of Switzerland (Zurich) and 401 students from the French-speaking part of Switzerland (Lausanne) after orthogonalization and normalization.

(Lausanne). There were virtually no between-center differences with respect to defeatism (zero on the y-axis), whereas students from Italy, Spain, the US and Argentina achieved, on average, higher activity scores compared to Swiss students. On the other hand, US-American students displayed, by far, the highest variation on the activity scale, while Spanish students exhibited the highest variation on the defeatism scale (fig. 3).

These findings were equally valid for male and female students. The respective mean values for males and females were found to be  $45.15 \pm 6.3$  versus  $47.50 \pm 6.9$  (activity:  $p < 0.0001$ ) and  $21.24 \pm 4.5$  versus  $21.41 \pm 4.5$  (defeatism:  $p = 0.4957$ , not significant). This is in line with the population differences described above. In fact, the male-female differences in activity can almost entirely be explained by the parameters population and recruitment procedure.

External validation is a critically important issue for this type of analysis since the derived structures, though remarkably robust, could nevertheless be artifactual and unrelated to the risk to health problems – in other words, they could be just another theoretical model of coping behavior. In consequence, we used the factors alcohol consumption, regular use of medicines, illegal drugs, impaired physical health, psychosomatic disturbances, im-

paired mental health and regular exercises, as quantitatively assessed through the 63 items of the ZHQ, in order to externally validate the above scales and to estimate the extent to which they are interrelated with consumption behavior and health problems. Across study sites, correlation analyses yielded a highly significant and consistent picture of the close relationship between insufficient coping skills on the one hand and the state of mental health on the other: the higher a person's defeatism score, the higher is his/her impairment in terms of mental health or psychosomatic disturbances. This is also true for physical health in 5 of 6 centers (table 5). Important here is that our focus was on *external validation*, and we did not aim to explain mental health problems through insufficient coping behavior.

Given the close association between defeatism and impaired mental health, high defeatism scores can be regarded as a risk factor for mental health problems in the sense of an unspecific vulnerability. In a first approach, we defined 'high defeatism' as  $\geq 1.3$  standard deviations above the mean in order to determine the percentage of students with insufficient coping behavior under chronic stress separately for each study site. We found 11.5% of the Italian students, 18.0% of the Spanish students and 12.0% of the Argentinean students to meet these criteria. It is worth noting, however, that these risk factors are neither a sufficient nor a necessary condition for the development of psychiatric disorders.

## Discussion

Using a study design of specific strengths with 3 independent and socioculturally diverse samples, our approach to quantifying basic coping behavior yielded convincing evidence for the existence of 2 personality traits activity and defeatism, which might enable the early detection of the 15% subgroup of the general population (here: 1,303 students) that exhibits insufficient coping behavior under chronic stress. Most items that make up the underlying scales showed an excellent discriminatory power, except for the 4 items assessing the role of religious and spiritual aspects when attempting to cope with difficult situations. Responses to these items showed in all 3 samples a certain amount of ambivalence (positive and negative feelings). This might either indicate that religious values are viewed differently in subgroups of these populations (positive coping mechanisms vs. signs of defeatism) or that the items' formulation leaves a certain margin of interpretation. In case of language problems,

**Table 5.** Insufficient coping skills versus general health

General health factor	Combined samples (n = 1,303)				Resilience-defeatism		
	passivity-activity		resilience-defeatism		Italy	Spain	Argentina
	correlation	p value	correlation	p value			
Regular tobacco consumption	-0.003	n.s.	0.143	<0.0001	0.181	0.186	0.025
Regular alcohol consumption	-0.056	0.044	0.140	<0.0001	0.198	0.114	0.078
Regular use of medicines	0.065	0.019	0.120	<0.0001	0.114	0.094	0.195
Illegal drugs	0.030	n.s.	0.184	<0.0001	0.247	0.216	0.057
Impaired physical health	0.043	n.s.	0.141	<0.0001	0.051	0.168	0.192
Psychosomatic disturbances	0.130	<0.0001	0.226	<0.0001	0.252	0.158	0.316
Impaired mental health	0.167	<0.0001	0.202	<0.0001	0.250	0.232	0.257
Regular exercise	0.066	0.031	-0.111	<0.0001	-0.026	-0.132	-0.140

Correlation analyses reveal a close relationship between insufficient coping skills on the one hand and state of general health, use of illegal drugs and lack of physical activity on the other (n = 1,303). The important point here is that the same pattern of correlations is consistently found across all study sites, i.e. in a socioculturally independent way. n.s. = Not significant.

rewording may improve the items' discriminatory power. However, given the highly consistent interrelations between defeatism on the one hand and impaired physical health, psychosomatic disturbances and mental health on the other, the modest cross talk between defeatism items and activity scale is of only theoretical interest.

The structural properties inherent in the COPE instrument appear to be socioculturally independent and equally valid for males and females, thus suggesting that the proposed COPE scales activity and defeatism reflect basic, evolutionarily ancestral and stable personality traits. This finding is of major practical relevance in view of the envisaged applications. The more so as our analyses were based on a sample of quite respectable size, and structural properties were determined through a sophisticated learning algorithm in combination with stringent cross-validation techniques. Interestingly, the percentage of students exhibiting insufficient coping behavior under chronic stress was very similar across the study sites (11.5–18.0%). On the other hand, the underlying scales showed certain population differences in terms of the activity-passivity characteristics in coping behavior. This is somewhat in line with earlier studies in the field where authors reported some evidence for cross-cultural differences [36–38]. The clinical relevance of such population differences, however, is unclear and has to be addressed by future studies.

The slightly higher between-subject variation observed among the students of the census survey might be explained through the recruitment procedure (thus replicating the results of our previous study [30]). It is worth

noting, however, that the structural properties of interest were found to be independent of the recruitment procedure.

The interrelations between insufficient coping behavior and impaired general health (NCDs) have been discussed in the literature for quite a long time [20, 39–43]. Therefore, it is not really surprising that our data revealed a close relationship between the newly constructed defeatism-resilience scale on the one hand and impaired physical health, psychosomatic disturbances and mental health on the other. In this study the focus was laid on external validation. We did not aim at explaining mental health problems through insufficient coping behavior. In fact, empirical data suggest that some 15–25% of the vulnerability to psychiatric disorders may be linked to insufficient stress management (varies with diagnosis, unclear causality) [4, 14, 23, 24, 26, 39]. In other words, it would be somewhat naïve to expect that coping behavior can explain a major proportion of physical and mental health problems. By contrast, our correlation analysis was critically important as an external validation criterion in order to demonstrate that the proposed scales for the quantitative assessment of coping behavior are linked to physical and mental health. Otherwise, the scales would be of no use for the envisaged clinical application.

The interrelation between defeatism and mental health problems cannot necessarily be interpreted in a causal way: for example, insufficient coping skills under chronic stress might well lead to mental health problems or, reversely, mental health problems might well cause insufficient coping behavior in stressful situations. However,

clinicians are primarily interested in reliable classification irrespective of whether or not the question of causality can be solved. As there is increasing and consistent evidence for a high comorbidity between major psychiatric disorders and somatic conditions (NCDs) like hypertension, type 2 diabetes mellitus, asthma and rheumatoid arthritis, amongst others [44–46], the observed correlation between the defeatism scale and impaired physical health deserves special attention. Insufficient coping behavior under chronic stress is neither a necessary nor sufficient condition for developing mental health problems. No more than an estimated 10–15% of the subjects (estimate based on data provided by the University of Zurich student statistics 1995–2010; a more reliable estimate can only be derived through prospective studies) showing insufficient coping will eventually receive a psychiatric diagnosis [30] and might benefit from early intervention before psychiatric symptoms develop and reach clinically relevant thresholds.

This study has two obvious limitations: (1) the data collected within the scope of this project stem from college and university students in the age range of 18–28 years. Therefore, the normative data and the prevalences reported in this manuscript must not necessarily apply to other age classes. Additional data may be required prior to applying the classifiers to older populations. (2) Though the proposed method of approach has demonstrated its sensitivity and specificity as to the detection of subjects with insufficient coping behavior under chronic stress, our data do not provide direct clues as to the extent to which the new COPE scales explain coping behavior. This latter point, however, was not a goal of this study.

Clearly, the exclusive use of self-report questionnaires in the assessment of both coping behavior and general health may have led to biased correlation estimates. As observer ratings do not solve those problems, our FP7 project (EU grant 248544) follows a 2-step approach: (1) COPE and ZHQ serve as screening instruments, and (2) risk cases are monitored over a 2-week period by a set of

psychophysiological sensors. The screening step allows us to narrow down on true risk cases among the students with insufficient coping skills (no more than an estimated 10–15% subgroup will eventually receive a psychiatric diagnosis). In a second step, these risk cases will be monitored over a 2-week period by psychophysiological sensors throughout their regular daily life. Sensors assess speaking behavior and voice sound characteristics once a day [47], along with continuous measures of heart rate, heart rate variability, blood pressure, physical activity, sleep quality, skin conductance and body temperature at a 5-min resolution over 24 h. Specifically, we are looking for well-defined events of interest, such as significant cardiovascular changes that are unrelated to physical activity.

## Conclusions

Given their stability and validity, the newly developed scales enable the quantification of basic coping behavior in a cost-efficient and reliable way, thus clearing the way for the early detection of subjects with insufficient coping skills under chronic stress who may be at risk of physical or mental health problems. Physical activity (regular exercise) is likely to play a significant role in early intervention programs. Our screening tools are available as online application in 5 languages through the website <http://www.ifrg.uzh.ch/WEBAPP/>. The web application will be available to universities on request. A prerequisite will be the availability of local contact persons who can provide specific information to help seekers.

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